Issued May 1971

SOIL SURVEY

Keokuk County, Iowa

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
IOWA AGRICULTURAL EXPERIMENT STATION

Major fieldwork for this soil survey was done in the period 1960–64. Soil names and descriptions were approved in 1966. Unless otherwise indicated, statements in this publication refer to conditions in the county in 1965. This survey was made cooperatively by the Soil Conservation Service and the Iowa Agricultural Experiment Station. It is part of the technical assistance furnished to the Keokuk County Soil Conservation District.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, USDA, Washington, D.C. 20250.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for agriculture, industry, and recreation.

Locating Soils

All the soils of Keokuk County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the capability unit and woodland group in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units.

Foresters and others can refer to the section "Woodland Management," where the soils of the county are grouped according to their suitability for trees.

Engineers and builders can find under "Use of the Soils for Engineering," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of Soils."

Newcomers in Keokuk County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given at the beginning of the publication.

Cover: A farm pond in an improved pasture in Keokuk County. This pond supplies water for livestock and for fishing and swimming. The soils near the pond are dominantly Ladoga and Adair.

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE IOWA AGRICULTURAL EXPERIMENT STATION

KEOKUK COUNTY is in the southeastern part of Iowa (fig. 1). It has an area of about 579 square miles, or 370,560 acres. Sigourney, the county seat, is located in the center of the county.

Most of the acreage in the county is in farms. About two-thirds of the county is in cultivated crops, and the rest is in pasture or timber or is used for some other purpose. Corn, soybeans, oats, and alfalfa are the principal crops. The farming consists mainly of grain and livestock production, and most of the grain is fed to livestock on the farms.

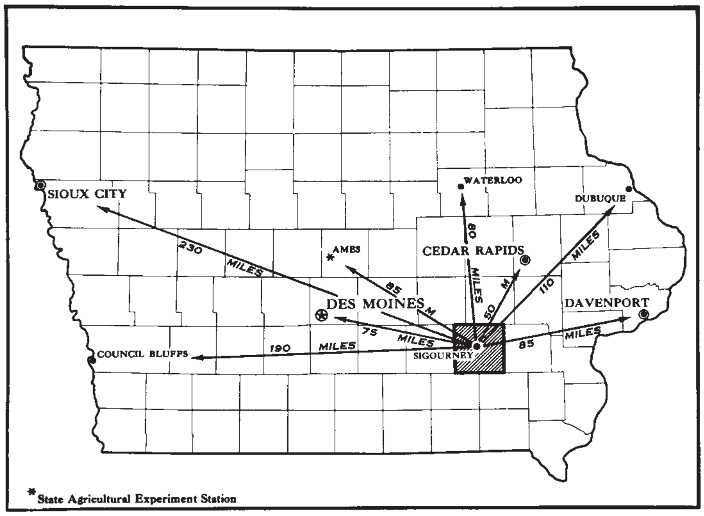

Figure 1.—**Location of Keokuk County in Iowa.**

The Climate of Keokuk County [1]

The stimulating climate of Keokuk County is a result of frequent changes in the air mass throughout the year. Because of its latitude and its location in the interior of the continent, the county has a wide annual range in temperature, maximum rainfall in summer, and a shift in the prevailing winds from southerly in summer to northwesterly in the colder half year.

Summers are warm and winters are cold, but prolonged periods of extreme heat or intense cold are rare. Minimum temperatures vary somewhat throughout the county, particularly on clear nights when farm lowlands may have a temperature several degrees lower than that of the uplands or of towns. Although the amount of moisture received from showers varies considerably within short distances, the seasonal total is about the same throughout the county. Otherwise, variations in climate are slight, and the record at Sigourney, summarized in table 1, is fairly representative of Keokuk County.

Temperatures vary markedly in Keokuk County through the year. The highest recorded temperature was 113° F. on July 22, 1901, and the lowest recorded temperature was 30° below zero on February 13, 1905, and again on December 28, 1924. A temperature of 90° or higher, which is too hot for best plant growth, occurs on an average of 31 days a year. A temperature of zero or colder is reported on an average of about 12 days a year. The average date of the first freeze in fall is October 12, and the average date of the last freeze in spring is April 28. The growing season averages 165 days.

About 70 percent of the annual precipitation falls from April through September, which is the cropping period. About 43 of the 48 days a year that have thunderstorms are also in the cropping period, and the thunderstorms may be accompanied by high winds, heavy rainfall, or hail. The probability of a tornado striking at any point in Keokuk County is estimated at about once in 1,000 years.

The most abundant rainfalls usually are in May and June. Periods of drought normally are in July or August, when there are a decrease in rainfall, a high moisture requirement for crops, and peak evaporation. Because growing corn requires about an inch of water a week, dry spells cause some concern in summer. This amount is received only about once in 4 weeks from late in July through August compared with once in 2 weeks from late in May through the early part of June. The heaviest recorded rainfall was 5.34 on June 12, 1946. Such a heavy rainfall probably will recur once in about 25 years. A rainfall of about 6.8 inches can be expected at any point in Keokuk County about once in 100 years. At any loca-

[1] Prepared by PAUL J. WAITE, State climatologist, U.S. Weather Bureau.

TABLE 1.—*Climatological*

[Based on records at Sigourney, Iowa, from

Month	Temperature in ° F.							Mean heating degree-days [2]
	Mean			Extreme				
	Daily maximum	Daily minimum	Monthly	Record highest		Record lowest		
				Degrees	Year	Degrees	Year	
January	32.3	14.3	23.3	62	1952 [3]	−22	1936	1,296
February	35.9	17.3	26.6	70	1932	−22	1933	1,075
March	46.9	26.7	36.8	86	1938 [3]	−16	1960	874
April	62.2	39.8	51.0	93	1965	16	1939	426
May	73.1	50.6	62.1	106	1934	26	1931	177
June	82.7	61.3	72.0	105	1934	41	1942 [3]	36
July	88.0	64.8	76.7	112	1934	45	1945 [3]	0
August	85.7	63.3	74.5	111	1934	40	1950	6
September	78.5	54.5	66.5	102	1939	25	1942	84
October	67.6	43.9	55.5	95	1938	17	1942	322
November	49.2	29.1	39.2	91	1938 [3]	−4	1937	774
December	36.3	18.9	27.9	69	1951	−16	1932	1,150
Year	61.5	40.4	51.0	112	1934	−22	1938 [3]	6,220

[1] Mean temperature based on 27 years of record in 30-year period. Rest of data based on entire 30-year period.
[2] Degree-days based on 65° F. The heating degree-days for a day are determined by substracting the average daily temperature from 65. These daily values are totaled to obtain the number of degree-days in a month.

tion the probable maximum rainfall in a 7-day period is about 11 inches. A measurable rain falls in about 103 days a year, and on the average, 61 of these days have 0.10 inch or more rainfall and 17 have 0.50 inch or more.

The average amount of snowfall received in the county is about 27.5 inches a year. Most of the snow falls from November through March. The first 1-inch snowfall in the year usually occurs about November 30.

At 15 feet above ground, windspeeds reach a maximum of about 50 miles per hour every other year and 75 miles per hour once in 50 years. Over open country these high winds may exist at crop level upon occasion.

Sunshine ranges from about 48 percent of the possible amount in December to about 75 percent in July. Relative humidity varies considerably, averaging about 50 percent at midafternoon and 85 to 90 percent at 5 a.m. August is usually the most humid month of the summer.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Keokuk County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. As they traveled over the county, they observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Mahaska and Otley for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man (*16*)[2]. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Otley silty clay loam, 2 to 5 percent slopes, is one of several phases within the Otley series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries

[2] Italic numbers in parentheses refer to Literature Cited, p. 105.

summary at Sigourney, Iowa

1931 through 1960[1]. Elevation 795 ft.]

Precipitation in inches						Mean number of days with—				
			Snow, sleet, hail				Temperatures			
Mean	Greatest daily	Year	Mean	Maximum monthly	Year	Precipitation of 0.10 inch or more	Maximum		Minimum	
							90° and above	32° and below	32° and below	0° and below
1.29	1.20	1960	7.4	19.2	1949	3	0	13	29	5
.95	1.10	1939	5.8	20.2	1960	3	0	10	26	3
1.98	1.46	1945	6.8	24.2	1951	5	0	4	22	1
2.71	2.10	1955	.4	5.0	1959	6	0	0	7	0
4.25	2.97	1954	(4)	.6	1944	8	1	0	1	0
4.92	5.34	1946	0	0	--------	8	6	0	0	0
3.33	4.00	1935	0	0	--------	6	11	0	0	0
4.00	4.25	1943	0	0	--------	6	9	0	0	0
2.93	2.55	1931	(4)	.5	1942	5	4	0	(5)	0
2.20	1.89	1941	(4)	(4)	1960 [3]	4	(5)	0	3	0
1.96	2.16	1934	2.0	14.0	1934	4	0	3	19	(5)
1.31	1.33	1941	5.5	11.8	1951	3	0	11	28	3
31.83	5.34	1946	27.5	24.2	1951	61	31	41	135	12

[3] Also on later dates, months, or years.
[4] Trace, an amount too small to measure.
[5] Less than one-half day.

accurately. The soil map in the back of this publication was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Only one such mapping unit is shown on the soil map of Keokuk County: the soil complex.

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Dickinson-Sparta complex, 2 to 5 percent slopes, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Alluvial land, channeled, is a land type in Keokuk County.

While a soil survey is in progress, soil scientists take soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are also assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. Yields under defined management are estimated for all the soils.

The soil scientists set up trial groups of soils on the basis of yield and practice tables and other data they have collected. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. Then they adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Keokuk County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect management.

The five soil associations in Keokuk County are described in the following pages.

1. Mahaska-Taintor Association

Nearly level, somewhat poorly drained and poorly drained soils that have a subsoil of silty clay loam and silty clay; formed in loess on uplands

This association consists mainly of nearly level soils on generally wide ridgetops, or divides. These divides are the highest elevations in the county. The larger areas of this association form the main divide between the South English River in the northern part of the county and the Skunk River in the southern part. Many smaller areas are on divides between the smaller drainage systems.

This association occupies about 13 percent of the county. About 50 percent is made up of Mahaska soils, 48 percent of Taintor soils, and 2 percent of minor soils.

The Mahaska soils developed in loess 12 to 15 feet thick (fig. 2). They have a thick, black to very dark gray surface layer and a grayish and brownish mottled subsoil. They occupy slightly convex areas bordering the level Taintor soils and are somewhat poorly drained. Mahaska soils are cultivated without additions of tile drains, but in years when rainfall is above average, artificial drainage is beneficial.

Taintor soils are in the most nearly level parts of this association. Like the Mahaska soils, they formed in a deposit of loess 12 to 15 feet thick. They have a thick, black surface layer and a grayish subsoil that is free of pebbles or stones. Taintor soils are poorly drained. Tile drains have been installed in most areas, but in a few places improved tile outlets and larger tile mains with less space between them are needed.

Among the minor soils in this association are the Sperry and Givin. The Sperry soils are in slightly depressional areas, typically less than 1 acre to 2 acres, in which water often ponds in spring. The somewhat poorly drained Givin soils are on the slightly convex, nearly level upland ridges and loess-covered high benches along streams.

All of the soils in this association have a high available moisture holding capacity.

The soils in the Mahaska-Taintor association generally are well suited to crops. Corn and soybeans are grown almost continuously; meadow crops are grown occasionally. Much of the corn is fed to hogs and beef cattle on farms within the county. Soybeans are used mainly as a cash grain crop. The only permanent pasture is in small lots near farmsteads. Since only a few farms are located entirely within this soil association, land use is sometimes determined by adjoining soils. Where ownership

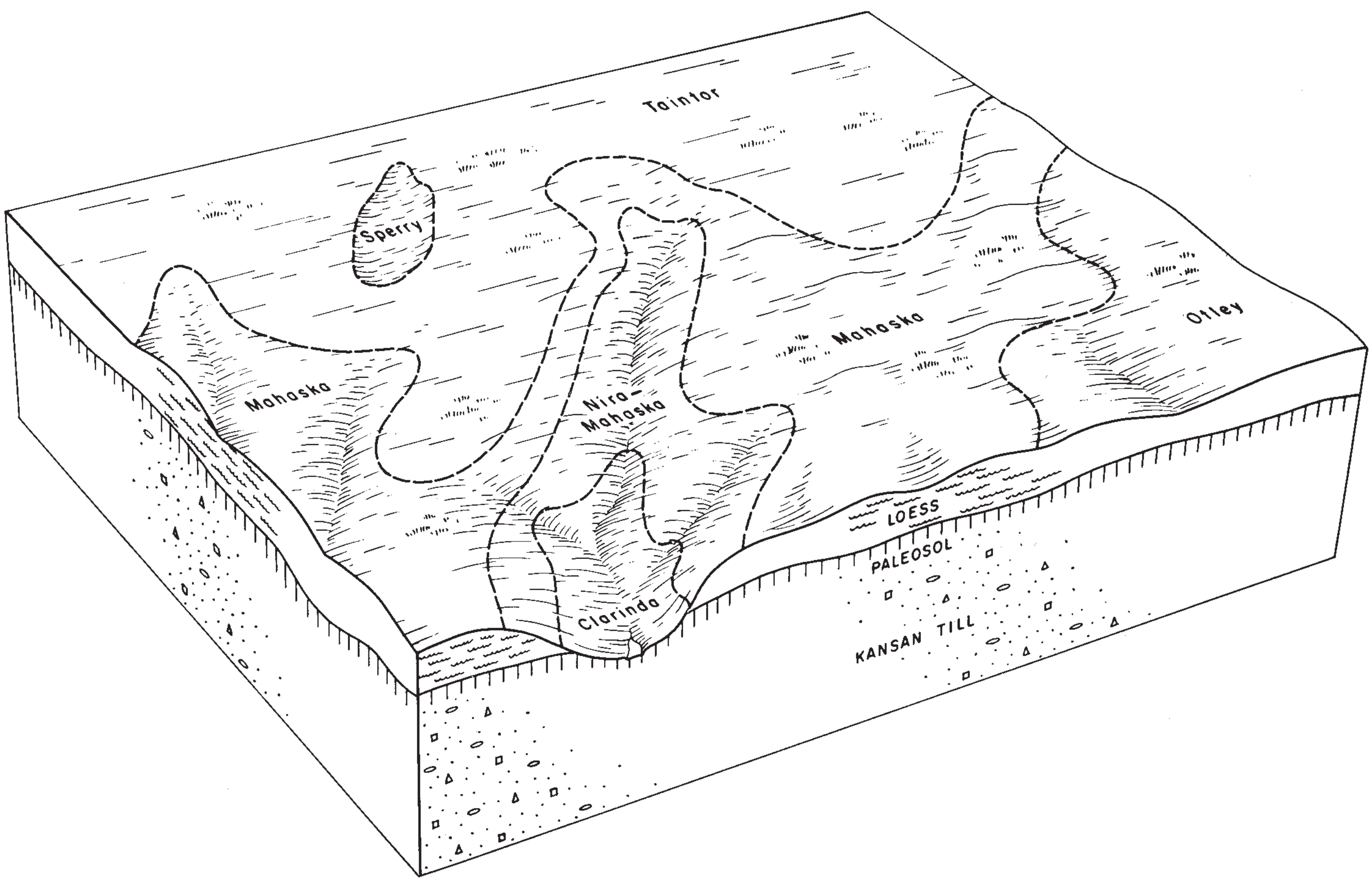

***Figure 2.*—Relationship of slope and parent material to soils of the Mahaska-Taintor association.**

and location of road boundaries permit it, some areas can be managed as large fields.

2. Otley-Clarinda-Adair Association

Gently sloping to steep, moderately well drained to poorly drained soils that have a subsoil of silty clay loam to clay; formed in loess and glacial till, dominantly on uplands

This association consists mainly of gently sloping soils on convex ridgetops and steep soils on side slopes that have many drainageways. These soils form an almost contoured pattern around the heads and sides of major drainageways.

This association occupies about 20 percent of the county. About 40 percent is made up of Otley soils, 15 percent of Clarinda soils, 15 percent of Adair soils, and 30 percent of minor soils.

Otley soils are moderately well drained soils that formed in loess on ridgetops and upper parts of side slopes. They have a dark-colored surface layer, except where eroded, and a brownish subsoil. Clarinda soils are poorly drained soils that formed in highly weathered, clayey glacial material. They lie lower on the slope than Otley soils (fig. 3). They have a grayish clayey subsoil and are eroded in many places. They tend to be seasonally wet and seepy. Adair soils formed in highly weathered, clayey glacial material. They have a brownish clayey subsoil, are seasonally wet, and are also eroded in many places.

Minor soils of this association are the Lamoni, Nira, Shelby, Colo, and Ely. The Lamoni, Nira, and Shelby soils occur as fairly large areas in drainageways; the Colo and Ely are closely intermingled in small drainageways in the side valleys. Areas of Colo and Ely soils generally are not large enough to farm separately.

All of the soils in this association have a high available moisture holding capacity. Drainage generally is adequate for most crops grown in the county, but in many places there is a narrow, seepy band near the contact zone of the loess and the weathered glacial till. These seeps are most prevalent in spring or when rainfall is above normal. Since the upland drainageways are often wet and seepy, tile drainage is beneficial when establishing seedings in waterways. Scattered trees and shrubs occur along some of the waterways and old fence rows. Erosion ranges from slight to severe on the soils in this association, and conservation practices are needed if soil losses are to be kept to a minimum.

Farming is diversified in this soil association, but grain and livestock are the main products. Much of the acreage is used for row crops and meadow grown in a rotation. Corn and soybeans are not grown so frequently as in the rotations used in soil association 1. Since most of the slopes in this association are long and uniform, the soils can be terraced, stripcropped, and tilled on the contour

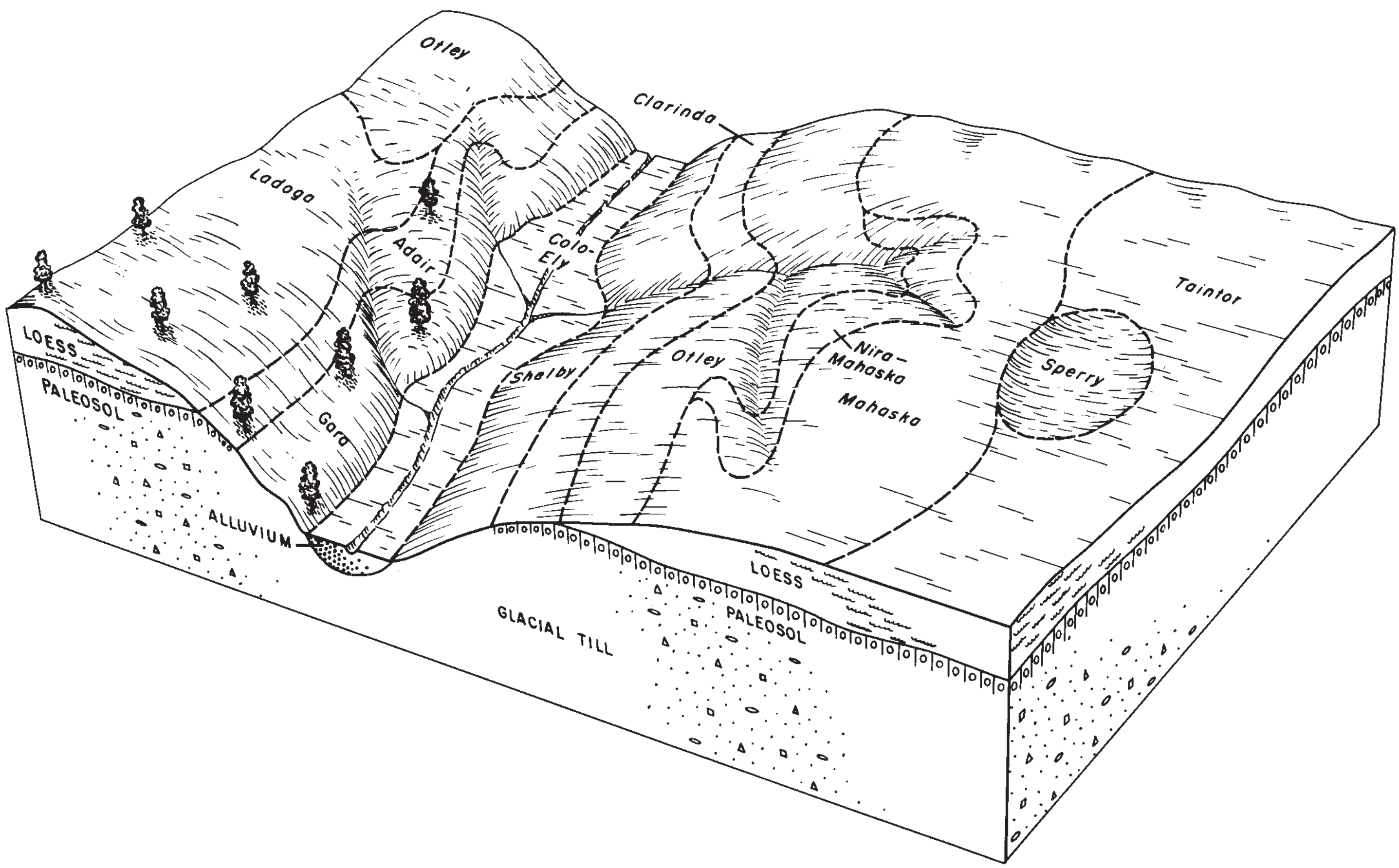

Figure 3.—**Relationship of slope, vegetation, and parent material to the soils of the Otley-Clarinda-Adair association.**

(fig. 4). Some fields are managed in a pattern that has rows across the major slopes. The landscape of this association is such that nearly all fields should be managed according to the lay of the land. Fence rows need to be relocated on contour lines.

The trend in this association is to combine small farms into larger ones. Some farm buildings are vacant, and farmers commonly operate more than one small farm unit.

***Figure 4.*—Typical landscape of the Otley soils in which there are parallel terraces on a slope and a well-kept farmstead in the background.**

3. Ladoga-Givin-Gara Association

Nearly level to steep, moderately well drained and somewhat poorly drained soils that have a subsoil of silty clay loam and clay loam; formed in loess and glacial till, dominantly on uplands

Typical in this soil association are nearly level and convex, sloping to steep soils on narrow side slopes of valleys. These slopes are dissected by drainageways. The main stems of upland drainageways are in this association, and gullies and noncrossable drains originated here. Trees are scattered in the drainageways and along fences in many places. Timber grows in a few, small, irregular areas, but most of the trees are near the farmsteads.

This association occupies about 20 percent of the county. About 70 percent is made up of Ladoga soils, 5 percent of Givin soils, 5 percent of Gara soils, and 20 percent of minor soils.

The Ladoga soils are moderately well drained and, except where eroded, have a very dark gray surface layer. They formed from loess on narrow ridgetops and the upper parts of convex side slopes. Givin soils are on the nearly level watershed divides and are somewhat poorly drained. They have a very dark grayish-brown surface layer and a grayish and brownish mottled subsoil. Gara soils formed in glacial till on strongly sloping to steep convex side slopes and narrow ridgetops. They are used for row crops less frequently than the Ladoga soils.

Also occurring in this association are fairly large acreages of Adair, Colo, and Ely soils. Adair soils, which tend to be seasonally wet and seepy, occur as narrow bands at the shoulders of slopes and on narrow ridgetops. Colo and Ely soils are closely intermingled in drainageways, generally in long and narrow areas. The Colo soils generally need tile drainage.

All the soils in this association have high available moisture holding capacity. Most soils on the ridgetops and upper slopes are moderately well drained, but in many places a narrow band of wet, seepy soil is near the contact zone of the loess and glacial till. Erosion ranges from slight to severe on the sloping soils, and conservation practices are needed to keep soil losses to a minimum (fig. 5).

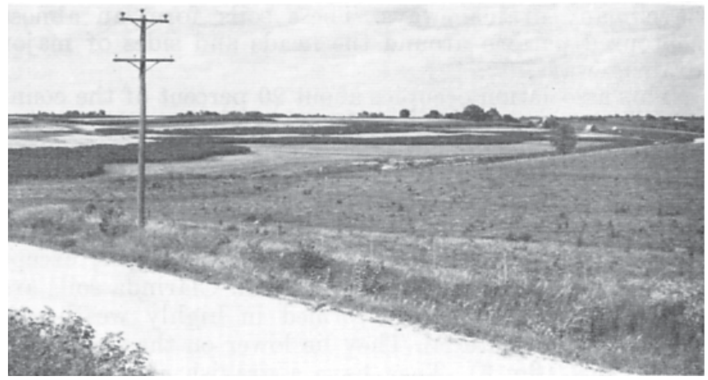

***Figure 5.*—A typical landscape of soil association 3. Ladoga soils are dominant, and Adair soils are on the steeper slopes. Contour stripcropping in the background.**

In most of the acreage, the soils in this association are suited to cultivated crops, but some of the strongly sloping or severely eroded soils are better suited to pasture. Crop growth is about average for the county. Many of the slopes are long and uniform and can be terraced, stripcropped, and tilled on the contour. Corn, the principal row crop, is generally grown in rotation with oats and meadow.

Ponds for watering livestock are numerous, and many farms have one or more of these ponds. Most farm buildings are occupied, but a few farmsteads are vacant.

4. Clinton-Keswick-Lindley Association

Sloping to very steep, moderately well drained soils that have a dominantly clay to sandy clay loam subsoil; formed in loess and glacial till on uplands

This association is confined to the hilly, strongly dissected areas that border flood plains of the South English and Skunk Rivers and their major tributaries. The main features of the association are narrow, rounded ridgetops; long, steep, convex side slopes; and narrow upland valleys. Also occurring are patches of forest, scattered trees in gullies and along fence rows; small, irregularly shaped fields; and a high proportion of pasture (fig. 6).

In most places the soils in this association developed under forest vegetation and have a light-colored surface layer. This association occupies about 32 percent of the county. About 60 percent is made up of Clinton soils, 15 percent of Keswick soils, 15 percent of Lindley soils, and 10 percent of minor soils.

Figure 6.—**An unimproved pasture in the Clinton-Keswick-Lindley soil association. Scattered trees are common in the drainageways.**

The Clinton soils were derived from loess and are mainly on the rounded ridgetops and the upper parts of convex side slopes (fig. 7). Keswick and Lindley soils formed from glacial till on steep and very steep side slopes.

Minor soils that developed from weathered stone and shale are the Boone, Gosport, Sogn, and Dunbarton. They are moderately well drained to excessively drained and occur on moderately steep and steep side slopes in the uplands. A few small limestone quarries are in this association, and, adjoining the English and Skunk Rivers, a few sandy areas are on steep slopes.

Most of the soils in this association are moderately well drained and have a high available moisture holding capacity. Runoff is rapid, and erosion is moderate to very severe. The contact zone between the loess and glacial till, or between the glacial till and the shale, is seasonally wet and seepy. Many waterways dissect this association. Deep active gullies having trees and brush growing along the sides are more numerous than in the other soil associations (fig. 8). The numerous ponds for watering livestock help to stabilize many of the gullies.

The soils in this association are not so well suited to row crops as are the soils in the other associations. Row crops are grown on the ridgetops and upper side slopes, but a large part of the acreage is in meadow, permanent pasture, and woodland.

Because this association has a smaller proportion of tillable, fertile soils than the other associations, land values are generally below the average for the county. Also, abandoned farmsteads are more commonplace. Some of the farms are along the edges of the larger valleys, and others are on the ridgetops. Many farmers use the soils in this association for pasture and use the adjoining bottom land for row crops.

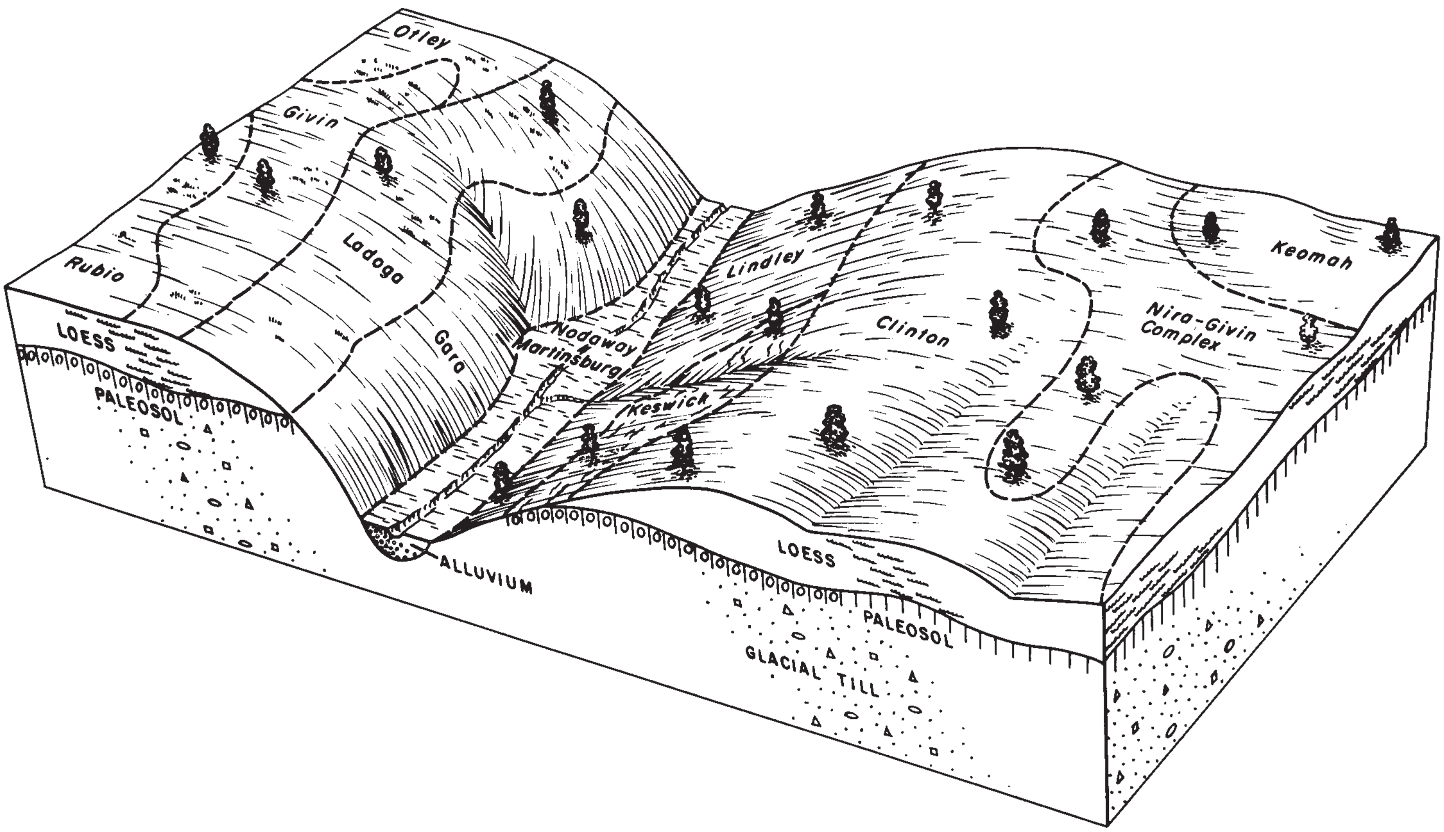

Figure 7.—**Relationship of slope, vegetation, and parent material to soils of the Clinton-Keswick-Lindley soil association.**

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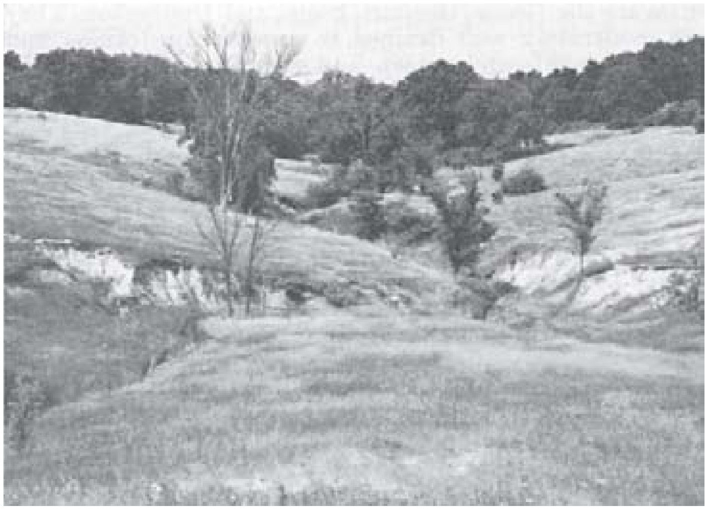

Figure 8.—**Deep, active gullies in an unimproved pasture in the Clinton-Keswick-Lindley soil association.**

5. Amana-Alluvial Land-Nodaway Association

Nearly level and undulating, well-drained to very poorly drained soils formed in alluvium on bottom lands

This soil association consists of nearly level soils on first and second bottoms (fig. 9). A high proportion of the acreage is in the valleys of the South English and Skunk Rivers and their tributaries. The soils formed from sediments that were deposited on the flood plains of the larger streams. The stream valleys range from less than ¼ mile to 2 miles wide. A generally timbered meander belt, normally less than a quarter mile wide, is along the North Skunk and South Skunk Rivers. This belt has many oxbows and bayous.

This association occupies about 15 percent of the county. About 20 percent is made up of Amana soils, 15 percent of Alluvial land, 10 percent of Nodaway soils, and 55 percent of minor soils.

The Amana soils have a dark-colored silt loam surface layer and a dark grayish-brown, silty subsoil. Alluvial land, a mixture of silty, sandy, and clayey material, adjoins the main channel of the stream and is frequently flooded. Oxbows, or remnants of former stream channels, occur in many places and are often ponded. In many places slight rises that follow the edges of these depressions form natural levees. The old levees and depressions left by the former meandering stream give this part of the bottom land a gently undulating topography. Some of the areas between the oxbows have been cleared and cropped.

The Nodaway soils have a thin, dark-colored silt loam surface layer. They show evidence of stratification caused by flooding, and they are well suited to crops if they are not flooded during the cropping season. Most of the flooding occurs early in spring before planting.

Minor soils in this association are in the Colo, Zook, Chequest, Humeston, Koszta, Radford, Vesser, Watkins, and Wabash series. These soils are dark colored and slowly permeable. The Colo and Zook soils are poorly drained, and the Wabash and Humeston soils are very

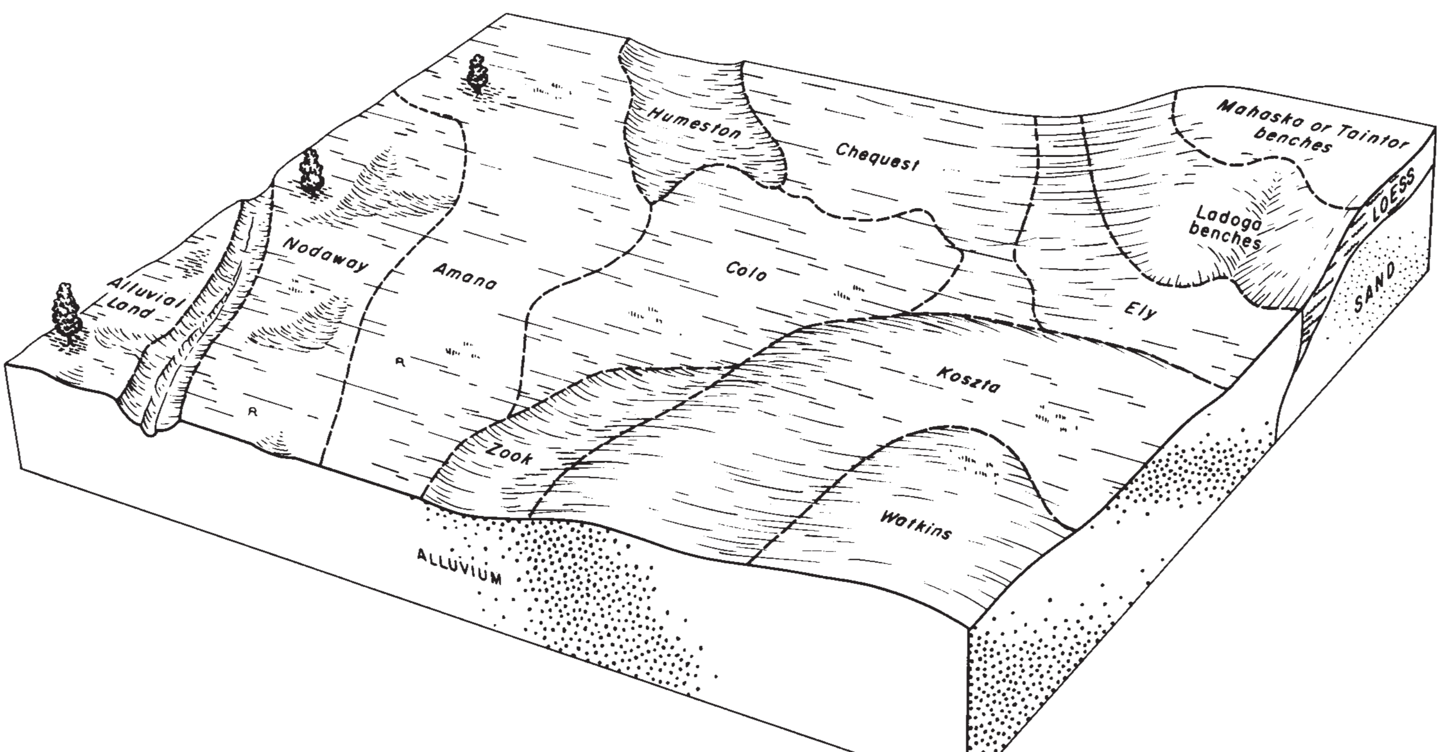

Figure 9.—**Relationship of slope, vegetation, and parent material to soils of the Amana-Alluvial land-Nodaway soil association.**

poorly drained. On these soils spring plowing is often delayed because of wetness. In much of the cropland, the soils are plowed in fall when their content of moisture is more favorable. The Zook and Wabash soils normally are some distance from the river channel near the base of foot slopes. The Vesser and Radford soils are somewhat poorly drained and are subject to flooding, and the Koszta and Watkins soils are moderately well and somewhat poorly drained and generally are not subject to flooding.

In all of this association except Alluvial land, the soils have a high available moisture holding capacity. Drainage ranges from good to very poor. In many places good tile outlets are difficult to establish. Except in meanders, flooding is infrequent on most of the bottom lands and row crops grow to maturity nearly every year.

Corn and soybeans are grown intensively on the tillable soils in this association. The rate of crop growth varies from year to year because of flooding but is generally above the county average.

Most fields in this association are rectangular, but other fields are irregular in shape and are bounded by uplands on one side and by a river on another. Many of the roads parallel the valleys and cross the rivers in only a few places. The farms are mainly on foot slopes or second bottoms. Farm buildings generally have feeding facilities for hogs and beef cattle. Farms tend to be larger than the average for the county, and there are some abandoned buildings in places. Land values range from high to low and are much more variable than in other associations.

Descriptions of the Soils

This section describes the soil series and mapping units in Keokuk County. The approximate acreage and proportionate extent of each mapping unit are given in table 2.

The procedure in this section is first to describe the soil series and then the mapping units in the series. Thus, to get full information on any one mapping unit, it is necessary to read the description of the unit and also the description of the soil series to which it belongs. The description of a soil series mentions features that apply to all the soils in the series. Differences among the soils of one series are pointed out in the descriptions of the individual soils or are indicated in the soil name. Unless otherwise stated, the descriptions of all mapping units in this section are for moist soils. As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. For example, Alluvial land, channeled, is a miscellaneous land type and does not belong to a soil series. It is, nevertheless, listed in alphabetic order along with the series.

An essential part of each soil series is the description of the soil profile, the sequence of layers beginning at the surface and continuing downward to the depth beyond which roots of most plants do not penetrate. Each soil series contains a short description of a typical soil profile and a much more detailed description of the same profile that scientists, engineers, and others can use in making highly technical interpretations.

TABLE 2.—*Approximate acreage and proportionate extent of the soils*

Soil	Acres	Percent
Adair clay loam, 5 to 9 percent slopes, moderately eroded	579	0. 2
Adair clay loam, 9 to 14 percent slopes, moderately eroded	15, 359	4. 1
Adair soils, 9 to 14 percent slopes, severely eroded	3, 375	. 9
Adair-Shelby complex, 14 to 18 percent slopes, moderately eroded	1, 202	. 3
Adair-Shelby complex, 14 to 18 percent slopes, severely eroded	551	. 2
Alluvial land, channeled	5, 463	1. 5
Alluvial land-Nodaway complex	2, 443	. 7
Amana silt loam	8, 597	2. 3
Amana silt loam, channeled	1, 895	. 5
Boone fine sandy loam, 10 to 20 percent slopes	423	. 1
Chelsea loamy fine sand, 9 to 18 percent slopes	133	(1)
Chequest silt loam, overwash	1, 275	. 3
Chequest silty clay loam	1, 769	. 5
Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded	1, 658	. 4
Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded	5, 370	1. 4
Clinton silt loam, 2 to 5 percent slopes	9, 875	2. 7
Clinton silt loam, 5 to 9 percent slopes	3, 211	. 9
Clinton silt loam, 5 to 9 percent slopes, moderately eroded	33, 405	9. 0
Clinton silt loam, 9 to 14 percent slopes	2, 266	. 6
Clinton silt loam, 9 to 14 percent slopes, moderately eroded	13, 105	3. 5
Clinton silt loam, 14 to 18 percent slopes, moderately eroded	843	. 2
Clinton silt loam, benches, 5 to 9 percent slopes, moderately eroded	250	. 1
Clinton soils, 5 to 9 percent slopes, severely eroded	938	0. 3
Clinton soils, 9 to 14 percent slopes, severely eroded	4, 920	1. 3
Clinton soils, 14 to 18 percent slopes, severely eroded	283	. 1
Colo silt loam, overwash	2, 930	. 8
Colo silty clay loam	818	. 2
Colo silty clay loam, 2 to 5 percent slopes	1, 638	. 4
Colo-Ely silty clay loams, 2 to 5 percent slopes	21, 409	5. 8
Dickinson-Sparta complex, 2 to 5 percent slopes	160	(1)
Dickinson-Sparta-Ladoga complex, 5 to 9 percent slopes, moderately eroded	556	. 2
Dickinson-Sparta-Ladoga complex, 9 to 14 percent slopes, moderately eroded	642	. 2
Dunbarton silt loam, 10 to 20 percent slopes, severely eroded	106	(1)
Ely silty clay loam, 3 to 7 percent slopes	2, 103	. 6
Gara loam, 9 to 14 percent slopes, moderately eroded	1, 104	. 3
Gara loam, 14 to 18 percent slopes	554	. 1
Gara loam, 14 to 18 percent slopes, moderately eroded	2, 419	. 6
Gara loam, 18 to 25 percent slopes, moderately eroded	375	. 1
Gara soils, 14 to 18 percent slopes, severely eroded	383	. 1
Givin silt loam, 1 to 3 percent slopes	5, 107	1. 4
Givin silt loam, benches, 1 to 3 percent slopes	650	. 2
Gosport silt loam, 14 to 25 percent slopes, moderately eroded	129	(1)
Humeston silt loam	460	

See footnote at end of table.

TABLE 2.—*Approximate acreage and proportionate extent of the soils*—Continued

Soil	Acres	Percent	Soil	Acres	Percent
Judson silty clay loam, 3 to 7 percent slopes	954	0. 2	Lindley loam, 18 to 25 percent slopes	1, 512	0. 4
Keomah silt loam, 1 to 3 percent slopes	1, 200	. 3	Lindley loam, 18 to 25 percent slopes, moderately eroded	2, 708	. 7
Keswick loam, 9 to 14 percent slopes	1, 600	. 4	Lindley loam, 25 to 40 percent slopes	467	. 1
Keswick loam, 9 to 14 percent slopes, moderately eroded	11, 225	3. 0	Lindley soils, 14 to 18 percent slopes, severely eroded	1, 343	. 4
Keswick soils, 9 to 14 percent slopes, severely eroded	4, 805	1. 3	Mahaska silty clay loam, 1 to 3 percent slopes	22, 933	6. 2
Keswick-Lindley complex, 14 to 18 percent slopes, severely eroded	1, 516	. 4	Mahaska silty clay loam, benches, 1 to 3 percent slopes	286	. 1
Keswick-Lindley loams, 14 to 18 percent slopes, moderately eroded	3, 080	. 8	Martinsburg silt loam, 2 to 5 percent slopes	438	. 1
Koszta silt loam, 1 to 3 percent slopes	1, 471	. 4	Martinsburg silt loam, 5 to 9 percent slopes	656	. 2
Ladoga silt loam, 2 to 5 percent slopes	15, 885	4. 3	Nira-Givin complex, 1 to 3 percent slopes	733	. 2
Ladoga silt loam, 5 to 9 percent slopes	1, 968	. 5	Nira-Mahaska silty clay loams, 1 to 3 percent slopes	439	. 1
Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	28, 740	7. 7	Nodaway silt loam	3, 688	1. 0
Ladoga silt loam, 9 to 14 percent slopes	271	. 1	Nodaway silt loam, channeled	713	. 2
Ladoga silt loam, 9 to 14 percent slopes, moderately eroded	3, 559	1. 0	Nodaway-Martinsburg silt loams, 2 to 5 percent slopes	6, 695	1. 8
Ladoga silt loam, benches, 2 to 5 percent slopes	453	. 1	Olmitz loam, 3 to 7 percent slopes	589	. 2
Ladoga soils, 5 to 9 percent slopes, severely eroded	259	. 1	Otley silty clay loam, 2 to 5 percent slopes	17, 737	4. 8
Ladoga soils, 9 to 14 percent slopes, severely eroded	251	. 1	Otley silty clay loam, 5 to 9 percent slopes	849	. 2
Lamoni silty clay loam, 5 to 9 percent slopes, moderately eroded	619	. 2	Otley silty clay loam, 5 to 9 percent slopes, moderately eroded	9, 119	2. 5
Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded	7, 097	1. 9	Otley silty clay loam, 9 to 14 percent slopes, moderately eroded	138	(1)
Lamoni soils, 9 to 14 percent slopes, severely eroded	849	. 2	Radford silt loam	1, 801	. 5
Lamoni-Shelby complex, 14 to 18 percent slopes, moderately eroded	174	. 1	Radford-Ely complex, 2 to 5 percent slopes	6, 239	1. 7
Lamont-Clinton-Chelsea complex, 5 to 9 percent slopes, moderately eroded	718	. 2	Rubio silt loam	1, 174	. 3
Lamont-Clinton-Chelsea complex, 9 to 14 percent slopes, moderately eroded	1, 204	. 3	Shelby loam, 14 to 18 percent slopes, moderately eroded	278	. 1
Lamont-Clinton-Chelsea complex, 14 to 18 percent slopes, moderately eroded	575	. 2	Sogn soils, 15 to 30 percent slopes	1, 382	. 4
Lamont-Clinton-Chelsea complex, 18 to 30 percent slopes, moderately eroded	466	. 1	Sperry silt loam	829	. 2
Lindley loam, 9 to 14 percent slopes, moderately eroded	480	. 1	Taintor silty clay loam	20, 925	5. 6
Lindley loam, 14 to 18 percent slopes	2, 566	. 7	Taintor silty clay loam, benches	249	. 1
Lindley loam, 14 to 18 percent slopes, moderately eroded	6, 118	1. 7	Tuskeego silt loam	578	. 2
			Vesser silt loam	2, 458	. 6
			Vesser silt loam, 2 to 5 percent slopes	1, 558	. 4
			Wabash silt loam, overwash	235	. 1
			Wabash silty clay loam	366	. 1
			Watkins silt loam, 0 to 2 percent slopes	290	. 1
			Watkins silt loam, 2 to 5 percent slopes	569	. 2
			Zook silt loam, overwash	1, 056	. 3
			Zook silty clay loam	696	. 2
			Total	370, 560	100. 0

[1] Less than 0.05 percent.

Following the name of each mapping unit, there is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit and woodland suitability group in which the mapping unit has been placed. The pages on which each of these groups are described can be found by referring to the "Guide to Mapping Units" at the back of this soil survey. Many terms used in the soil descriptions and other sections of this survey are defined in the Glossary at the back of this soil survey and in the "Soil Survey Manual" (*16*).

Adair Series

The Adair series consists of moderately well drained to somewhat poorly drained soils that formed from the subsoil of old buried soils. This subsoil is firm and very firm and contains a large amount of clay. The buried soils formed earlier in weathered glacial till. Adair soils have convex slopes of 5 to 18 percent. Most areas occur as bands along side slopes, but in some places these soils are on convex ridgetops. These soils are downslope from loess-derived Otley soils and upslope from till-derived Shelby or Gara soils. In some places, Adair soils are mapped in a complex with Shelby soils.

In a typical profile the surface layer is about 11 inches thick and consists of very dark brown and very dark grayish-brown, firm clay loam. The subsoil extends to a depth of about 52 inches. It is dark-brown or brown, very firm clay in the upper part; dark-brown or brown and yellowish-brown, firm clay loam in the middle; and yellowish-brown, firm clay loam in the lower part. The upper part of the subsoil is mottled with yellowish red and yellowish brown, and the lower part is mottled with weak red and dark gray. The underlying material is

dark-brown to brown and yellowish-brown, firm clay loam. A few stones and pebbles are present in the subsoil and underlying material.

Adair soils have a high available moisture holding capacity and are very slowly to slowly permeable. The surface layer generally is acid unless recently limed. The subsoil normally is medium acid to strongly acid, but in some places it is neutral or mildly alkaline and calcareous at a depth of 40 inches or more. In most places Adair soils are low in available nitrogen and very low in available phosphorus and available potassium.

Typical profile of an eroded area of an Adair clay loam, 351 feet east and 76 feet south of the northwest corner of the NW¼NE¼ section 25, T. 77 N. R. 13 W., on slope of 8 percent that is convex and faces southeast:

Ap—0 to 7 inches, very dark brown (10YR 2/2) clay loam, very dark grayish brown (10YR 3/2) when kneaded; few, fine, faint mottles of dark brown or brown (10YR 4/3) and few, fine, prominent mottles of reddish brown (5YR 4/3); weak, fine, granular structure; firm; few fine concretions of manganese oxide; neutral; abrupt, smooth boundary.

A3—7 to 11 inches, very dark grayish-brown (10YR 3/2) and reddish-brown (5YR 4/4) heavy loam, dark brown (7.5YR 3/2) when kneaded; common, fine, faint mottles of yellowish red (5YR 4/6); weak, fine and very fine, subangular blocky structure; firm; few fine concretions of manganese oxide; medium acid; gradual, smooth boundary.

IIB21t—11 to 22 inches, dark-brown or brown (7.5YR 4/4) gritty clay; few, fine, distinct mottles of yellowish red (5YR 4/6) and common, fine, distinct mottles of yellowish brown (10YR 5/8); moderate, very fine, subangular and angular blocky structure; very firm; few fine concretions of manganese oxide; thin, discontinuous clay films; medium acid in upper part to strongly acid in lower part; gradual, smooth boundary.

IIB22t—22 to 31 inches, dark-brown or brown (7.5YR 4/4) and yellowish-brown (10YR 5/8) heavy clay loam; weak, medium, prismatic breaking to weak, very fine, subangular blocky structure; firm; common fine concretions of manganese oxide; pebbles (½ inch to 1½ inches in diameter); thin, discontinuous clay films; dark-gray (10YR 4/1) clay in old root channels; strongly acid; gradual, smooth boundary.

IIB31t—31 to 52 inches, yellowish-brown (10YR 5/4) medium clay loam; few, fine, distinct mottles of weak red (2.5YR 5/2) and few, fine, distinct mottles of dark gray (10YR 4/1); weak, medium, prismatic structure; firm; common fine and few medium concretions of manganese oxide; common, large, polished, white pebbles; few smaller pebbles (½ inch to 1½ inches in diameter); dark-gray (10YR 4/1) clay in old root channels; medium acid in upper part grading to neutral in lower part; gradual, smooth boundary.

The Ap or A1 horizon ranges from silt loam or loam to clay loam or gritty silty clay loam. In some places the B horizon is dark brown to reddish brown and has many red and yellowish mottles. The lower part of the B horizon and the C horizon range from dark brown to yellowish brown and are clay loam in texture. The grayish mottles typically are within a depth of about 30 inches. These soils are strongly acid in the most acid part of the profile and typically are leached to a depth of 4 feet or more.

Adair soils are more clayey, less permeable, and firmer than Shelby soils and are redder in the subsoil. They are darker colored in the surface layer than Keswick soils and lack a grayish subsurface layer. Adair soils are less gray in the subsoil than Lamoni and Clarinda soils.

Adair clay loam, 5 to 9 percent slopes, moderately eroded (AaC2).—This soil has the profile described as typical for the series. It is slowly permeable to very slowly permeable. Runoff is excessive, and the hazard of erosion is severe. Seasonal seeps occur in many places.

This soil is on slopes near the ends of extended ridgetops, generally slightly below the surrounding ridges. It extends down to the bottoms of small streams in some places.

Included with this soil in mapping are a few eroded areas where the reddish-brown or yellowish-brown former subsoil is at the surface. Also included, at the heads of waterways, are soils that have a gray clay subsoil. Other included areas are of an Adair soil that has a gritty silty clay loam surface layer.

Adair clay loam, 5 to 9 percent slopes, moderately eroded, is moderately well suited to hay or pasture. It is poorly suited to row crops, though row crops can be grown where this soil is terraced. Crops generally do not grow well, but they respond to additions of manure and fertilizer if surface seepage is reduced.

Because of wetness, this soil must be worked later in spring than most of the adjoining soils. The wetness is normally reduced by interceptor tile drains installed in the higher, more permeable Ladoga or Otley soils. Although tilth is generally poor, it can be improved by additions of manure and use of more meadow crops. Row crops and new seedings need additions of a complete fertilizer. Established stands containing legumes need large additions of phosphorus. (Capability unit IIIe-2; woodland suitability group 7)

Adair clay loam, 9 to 14 percent slopes, moderately eroded (AaD2).—This soil has a very dark grayish-brown surface or plow layer 5 to 7 inches thick. The subsoil is yellowish-brown to reddish-brown clay loam to clay that is slowly permeable to very slowly permeable. Runoff is rapid, and the hazard of erosion is severe.

This soil occurs in bands or strips in a contour pattern immediately below the loess-till contact line. It generally lies below the loess-derived Otley or Ladoga soils and above the Shelby and Gara soils, Colo-Elv silty clay loams, 2 to 5 percent slopes, and Radford-Ely complex, 2 to 5 percent slopes.

Included with this soil in mapping are small areas of Colo-Ely silty clay loams, 2 to 5 percent slopes, and of Radford-Ely complex, 2 to 5 percent slopes. Also included are small areas of Adair soils that have a thicker, darker surface layer than this Adair clay loam and areas that have a gritty silty clay loam surface layer. In some places the reddish-brown to yellowish-brown subsoil is exposed. Included at the heads of drainageways are soils that have a gray clay subsoil.

This Adair soil is used as cropland and for pasture. It is not well suited to row crops, but they can be grown without excess erosion if terraces are constructed and contour tillage is used. Seedbeds are difficult to prepare.

Because of wetness, this soil often must be worked later in spring than most adjoining soils. Artificial drainage is needed in places. Surface wetness normally is reduced by interceptor tile drains. This soil generally is in poor tilth, but tilth can be improved by adding manure and by growing more meadow crops. Row crops and new seedings need additions of a complete fertilizer. Established stands containing legumes need large additions of phosphorus. (Capability unit IVe-2; woodland suitability group 7)

Adair soils, 9 to 14 percent slopes, severely eroded (AdD3).—These soils have a dark grayish-brown to dark yellowish-brown plow layer 5 to 7 inches thick. This plow layer ranges from heavy clay loam to clay and is sticky when wet.

These soils occur in bands or strips just below the loess-till contact line. They generally lie below the loess-derived Otley or Ladoga soils and above the Shelby and Gara soils, Colo-Ely silty clay loams, 2 to 5 percent slopes, and Radford-Ely complex, 2 to 5 percent slopes. Small areas of these associated soils are included in mapping. Also included are areas that have a darker, more friable surface layer than these soils and, at the heads of drainageways, small areas of soils that have a gray subsoil.

These severely eroded Adair soils are better suited to hay and pasture than to row crops. Before establishing a new seeding of pasture, they occasionally can be used for a row crop. Since tilth is poor, manure is needed for improving tilth and for helping to establish seedings. Established stands containing legumes need large additions of phosphorus. Because these soils are seepy and wet, establishing and maintaining seedings are difficult. Interceptor tile is used to help control the seepage water. (Capability unit VIe–1; woodland suitability group 7)

Adair-Shelby complex, 14 to 18 percent slopes, moderately eroded (AhE2).—The surface layer of the soils in this complex ranges from clay loam to loam and is normally very dark grayish brown to brown. Slopes are irregular. The Adair soils occur on the upper part of the slopes, have a reddish-brown to yellowish-brown clay loam subsoil, and are slowly to very slowly permeable. The Shelby soils occur on the lower part of slopes and generally have a yellowish-brown clay loam subsoil that is moderately slow in permeability. Adair soils make up about 65 percent of this complex and Shelby soils most of the rest.

Soils in this complex occur just below the loess-till contact line, generally below the Otley or Ladoga soils and above Colo-Ely silty clay loams, 2 to 5 percent slopes, and Radford-Ely complex, 2 to 5 percent slopes. Included with this Adair-Shelby complex in mapping are areas of an Adair soil that has a slightly thicker and darker surface layer.

The soils of this complex are generally in pasture, but some areas are in crops. These soils are better suited to pasture or hay than to row crops because the erosion hazard is severe. Tilth varies from place to place. In some places these soils are hard and cloddy when dry and clayey and sticky when wet. (Capability unit VIe–1; woodland suitability group 7)

Adair-Shelby complex, 14 to 18 percent slopes, severely eroded (AhE3).—The surface layer of the soils in this complex is dark grayish brown to yellowish brown and 3 to 6 inches thick. Texture of the surface layer ranges from clay loam to clay in the Adair soils and from loam to clay loam in the Shelby soils. The subsoil of the Adair soils is generally reddish-brown to yellowish-brown clay loam that is slowly to very slowly permeable. The subsoil of the Shelby soil generally is yellowish-brown, slowly permeable clay loam. Adair soils make up about 65 percent of this complex, and Shelby soils most of the rest.

This complex occurs immediately below the strongly sloping, loess-derived Otley or Ladoga soils. It also occurs above Colo-Ely silty clay loams, 2 to 5 percent slopes, and Radford-Ely complex, 2 to 5 percent slopes, in narrow drainageways. Areas of these complexes are included in mapping. Also included are soils that have a slightly thicker and darker surface layer than that in this Adair-Shelby complex. In some places this complex is dissected by noncrossable gullies.

Some areas of this complex are still used for row crops, though the soils are not suited to them. These soils are only moderately well suited to pasture or hay. They can be used for plantings that provide food and cover for wildlife.

Because these soils are in poor tilth and have a clayey surface layer that is sticky when wet, seedbeds are difficult to prepare, especially where the clayey subsoil is exposed. (Capability unit VIIe–1; woodland suitability group 7)

Alluvial Land, Channeled

Alluvial land, channeled (Al) consists mostly of light-colored deposits of silt or sand over mixtures of silt, sand, and silty clay. Slopes range from 0 to 2 percent. The land occurs mostly on bottoms along the Skunk River, but it also is along the channels of other major streams. From time to time overflowing streams either scour this land or deposit new material. Included with this land in mapping are some areas of Nodaway soils.

This land usually is wet because of frequent flooding, seepage, and ponded water. In most places it is dissected by numerous uncrossable streams and channels and by old bayous that are often filled with water. It is undulating in many areas where sand bars occur.

Trees grow in thick stands on Alluvial land, channeled, in most places. Unless the trees are removed and grass is established, this land has little value as pasture. It provides a good habitat for wildlife. The supply of plant nutrients is variable. (Capability unit Vw–1; woodland suitability group 9)

Alluvial Land-Nodaway Complex

Alluvial land-Nodaway complex (Am) is adjacent to the main channels of the major streams or is in areas where the streams have meandered. In some places these meanders are readily evident, though generally they have been silted enough to permit cultivation. Slopes range from 0 to 2 percent.

The Alluvial land in this complex consists of alluvium recently deposited by streams on first bottoms. In most places this land has a light-colored silty to sandy surface layer over mixtures of sand, silt, and silty clay. Overflowing streams scour this land or deposit new material from year to year. Areas of Nodaway soils consist of stratified silt loam that extends to a depth of 30 inches or more.

Some of this complex is cleared and used intensively for row crops, but most of it is in trees or trees mixed with pasture. The soils are only moderately well suited to row crops. Because the hazard of flooding is moderate to severe, many areas are too wet for good growth of crops. In adequately drained areas where flooding is controlled, these soils are well suited to corn and soy-

beans, but reducing flooding is not practical in many places, especially on the bottom lands along the Skunk River. Trees grow in thick stands in most areas. Unless the trees are removed and grasses established, the value of these soils for pasture is very low. Nutrient levels vary, but these soils provide a good habitat for a variety of wildlife. (Capability unit Vw–1; woodland suitability group 9)

Amana Series

The Amana series consists of somewhat poorly drained soils that developed from silty alluvium containing little sand. The native vegetation is trees and grasses. These soils are on old levees and meander belts that have slopes of 0 to 2 percent and that normally parallel the major streams and tributary channels.

In a typical profile the surface layer, about 18 inches thick, is black and very dark brown silt loam. The subsoil is friable light silty clay loam that is dark grayish brown, dark gray, or gray. The underlying material is mottled gray and yellowish-brown silt loam.

Amana soils have a high available moisture holding capacity and are moderately permeable. The surface layer generally is slightly acid to neutral. The subsoil is strongly acid in the most acid part, and the underlying material is slightly acid to neutral. These soils are low in available nitrogen, low to medium in available phosphorus, and low in available potassium.

Typical profile of Amana silt loam, 1,020 feet south and 40 feet east of the northwest corner of the SW¼, section 15, T. 77 N., R. 12 W.:

Ap—0 to 10 inches, black (10YR 2/1) silt loam; moderate, fine, granular structure; friable; neutral; clear boundary.

A3—10 to 18 inches, heavy silt loam that is mostly very dark brown (10YR 2/2) but is dark grayish brown (10YR 4/2) in 20 percent of the horizon; weak, very fine, subangular blocky to moderate, fine, granular structure; friable; slightly acid; gradual boundary.

B1—18 to 24 inches, dark grayish-brown (10YR 4/2) light silty clay loam; few, fine, faint mottles of dark yellowish brown (10YR 4/4) and few, fine, distinct mottles of dark brown (7.5YR 4/4); moderate, very fine, subangular blocky structure; friable; fine, hard, dark concretions of an oxide; medium acid; gradual boundary.

B21—24 to 30 inches, dark grayish-brown (10YR 4/2) and dark-gray (10YR 4/1) light silty clay loam; few, fine, faint mottles of dark brown (10YR 4/3); weak, fine, subangular blocky structure; friable; dark-gray color is from silty coats on peds; few, fine, hard concretions of a dark oxide; medium acid; gradual boundary.

B22—30 to 41 inches, dark grayish-brown (10YR 4/2) and dark-gray (5Y 4/1) light silty clay loam; common, fine, distinct mottles of olive brown (2.5Y 4/4) and few, fine, distinct mottles of dark yellowish brown (10YR 4/4) and strong brown (7.5Y 5/6); moderate, fine, subangular blocky structure; friable; dark-gray color is from silty coats of peds; common concretions of a dark oxide; slightly acid; gradual boundary.

B3—41 to 51 inches, dark grayish-brown (2.5Y 4/2) and gray (5Y 5/1) light silty clay loam; many, fine, prominent mottles of yellowish brown (10YR 5/6) and common mottles of strong brown (7.5YR 5/6); weak, medium, subangular blocky structure; friable; gray color is from silt coats on peds; common concretions of a dark oxide; slightly acid; gradual boundary.

C—51 to 65 inches, mottled gray (5Y 6/1) and yellowish-brown (10YR 5/4) heavy silt loam; common, fine, distinct mottles of strong brown (7.5YR 5/8); massive; friable; common concretions of a dark oxide; slightly acid to neutral.

The A horizon of Amana soils ranges from silt loam to light silty clay loam in texture and from 12 to 20 inches in thickness. Color ranges from black to dark gray or dark grayish brown. In most places mottles are few to common in the upper part of the B horizon, and they increase in intensity with depth. Soil material coarser textured than light silty clay loam occurs at a depth of 3½ to 4 feet. The C horizon is massive silt loam that is stratified in places. The profile of Amana soils is medium acid to strongly acid in its most acid part.

Amana soils lack the grayish subsurface layer that occurs in the Vesser soils and have less clay in the subsoil. They have less clay in the surface layer and subsoil than the Colo soils. The surface layer of the Amana soils is lighter colored when dry than that of Colo soils, which are less acid than the Amana soils.

Amana silt loam (An).—This soil has a very dark brown to brown or a dark grayish-brown silt loam surface layer 12 to 20 inches thick. The subsoil is silt loam that generally is a slightly lighter colored dark grayish brown than the surface layer. The profile of this soil is generally medium acid to very strongly acid in its most acid part. Included with this soil in mapping are some areas that have a silty clay loam surface layer.

Amana silt loam is on first bottoms along the major streams in the county and their tributaries. It occurs closely with the Nodaway and Chequest soils, Alluvial land-Nodaway complex, or Alluvial land, channeled. Slopes range from 0 to 2 percent.

This soil is medium in organic-matter content and fertility. Generally, the surface layer is friable and easy to work. Crops normally respond well to additions of fertilizer.

This soil is well suited to row crops and is used intensively for corn and soybeans. Flooding is a hazard, but it occurs early in most years and does not seriously interfere with cropping. A few areas are in pasture and trees.

Protection from flooding is needed in many areas of this soil. Areas that are only slightly wet can be improved by installing tile lines, which work well if suitable outlets are available. (Capability unit I–2; woodland suitability group 9)

Amana silt loam, channeled (Ao).—This soil ocurs on level to slightly undulating first bottoms along major streams in old meander areas. It is associated with Alluvial land-Nodaway complex and with Nodaway and Chequest soils. This soil is cut up by meandering stream channels and in some places by old water-filled bayous that cannot be crossed with farm machinery. Streambanks are still being cut in some areas and may have small sandbars adjacent to them.

The surface layer of this soil is similar to the one described as typical for the series, but in places, there is a layer of silty overwash generally less than 3 inches thick. The surface layer normally is friable and easy to work. Content of organic matter is medium.

Most of this soil is forested with trees of low quality. Some areas are in mixed grass and trees and are used for pasture, but the pasture is also of low quality. Cultivating this soil is practical in some areas where trees have been removed and old channels filled and straightened. (Capability unit Vw–1; woodland suitability group 9)

Boone Series

The Boone series consists of well-drained to somewhat excessively drained soils that developed from material weathered from sandstone. These soils are on the lower part of convex slopes of 10 to 20 percent. They occur in upland areas that border the valleys of the Skunk River and its tributaries. The native vegetation was trees.

In a typical profile the surface layer, about 7 inches thick, is dark grayish-brown and dark-brown to brown, very friable fine sandy loam. The subsurface layer, about 3 inches thick, is dark-brown to brown, very friable fine sandy loam. The subsoil extends to a depth of about 25 inches and is loose fine sand and medium sand. It is mixed dark brown to brown, brown, and pale brown in the upper part and mottled yellowish brown, strong brown, and yellowish red in the lower part. The underlying material is partly distintegrated sandstone that grades to soft to moderately hard sandstone within a depth of about 40 inches. The strong-brown and yellowish-red colors of the sandstone are in horizontal bands.

Boone soils have a low available moisture holding capacity. They are moderately permeable to rapidly permeable. The surface layer is slightly acid to medium acid, the subsoil is medium acid to strongly acid, and the underlying material is medium acid in most places. These soils are very low in available nitrogen, available phosphorus, and available potassium. They are not suited to crops.

Typical profile of Boone fine sandy loam, 440 feet west and 620 feet north of the southeast corner of the NE¼SE¼, section 10, T. 74 N., R. 12 W., on a 15 percent slope that faces northwest:

A1—0 to 7 inches, dark grayish-brown (10YR 4/2) and brown (10 YR 4/3) fine sandy loam, light brownish gray to light gray (10YR 6/2 to 7/2) when dry, dark brown to brown (10YR 4/3) when kneaded; weak, medium, platy structure that breaks to weak, fine, granular structure; very friable; slightly acid; clear, smooth boundary.

A2—7 to 10 inches, dark-brown to brown (10YR 4/3) fine sandy loam, light gray (10YR 7/2) when dry; weak, medium, platy structure that breaks to weak, fine, granular structure; very friable; medium acid; gradual, smooth boundary.

B1—10 to 18 inches, mixed dark-brown (10YR 4/3), brown (10YR 5/3), and pale-brown (10YR 6/3) fine sand, brown (10YR 5/3) when kneaded; single grain (structureless); loose; some clay bridging between sand grains (weakly coherent); medium acid; gradual, smooth boundary.

B2t—18 to 25 inches, mottled yellowish-brown (10YR 5/6), strong-brown (7.5YR 5/6), and yellowish-red (5YR 5/8) fine and medium sand; single grain (structureless); loose; some clay bridging between sand grains (slightly coherent); medium acid; clear, wavy boundary.

C—25 inches +, stratified horizontal bands of strong-brown (7.5YR 5/8) and yellowish-red (5YR 5/8), soft, partly disintegrated sandstone that grades to soft to moderately hard sandstone within a depth of 40 inches; at 60 inches sandstone is brownish yellow (10YR 6/8) and has yellowish-red (5YR 5/8) coatings in vertical cleavages along old root channels; medium acid.

The A1 horizon typically is dark grayish brown, but ranges to very dark gray and very dark grayish brown where the horizon is less than 6 inches thick. The A horizon is fine sandy loam or loamy fine sand. The A2 horizon is mixed into the plow layer in many places, but where present, it ranges from very dark grayish brown to brown. The B1 horizon ranges from dark brown to pale brown, and the B2 horizon from yellowish brown to yellowish red. The B horizon ranges from loamy fine sand to loose fine and medium sand. It has low base saturation. Depth to weathered sandstone ranges from 20 to 36 inches, but fragments of unweathered sandstone may be present throughout the solum and also scattered on the soil surface. These soils are leached; reaction ranges from medium acid to strongly acid in the most acid part of the profile.

Boone soils differ from Dunbarton soils in having a sandy surface layer and subsoil and a subtratum of sandstone bedrock, whereas Dunbarton soils have a loamy surface layer, a clayey subsoil, an underlying material consisting of unconsolidated limestone flagstones. In contrast to Chelsea soils, Boone soils have fragments of unweathered sandstone mixed in the surface layer and subsoil and have somewhat cemented sandstone above a depth of 40 inches.

Boone fine sandy loam, 10 to 20 percent slopes (BoE).—This soil is rapidly permeable and well drained to somewhat excessively drained. It is on uplands below the strongly sloping Clinton soils and above soils of the first bottoms that are adjacent to the major streams in the county. It also occurs above Nodaway-Martinsburg silt loams, 2 to 5 percent slopes, and Radford-Ely complex, 2 to 5 percent slopes, in narrow drainageways that empty into the major streams. This soil normally occurs on the same slopes as Lindley soils.

Included with this soil in mapping are areas of Boone soils in which the surface layer is both thinner and thicker and coarser textured than that in the profile described as typical for the Boone series. Also included are several areas that are only strongly sloping and a few areas that have a thin mantle of loess.

Nearly all of this soil is used for pasture, but a small acreage is in trees. This soil is not suitable for row crops. It is very low in fertility, and crops respond poorly to additions of fertilizer. Because slopes are steep and the water holding capacity is low, runoff is rapid and the hazard of erosion is very severe. This soil should not be used as a site for structures meant to hold water, especially farm ponds. (Capability unit VIIs–1; woodland suitability group 6)

Chelsea Series

The Chelsea series consists of excessively drained sandy soils that formed under trees. These soils developed from eolian sand, or sand reworked by wind. They are in the uplands adjacent to the major stream valleys. Slopes are convex and range from 9 to 18 percent. These soils are closely associated with Lamont and Clinton soils and, in some places, are mapped with them in complexes.

In a typical profile the surface layer is 3 inches thick and consists of dark grayish-brown and dark-brown loamy fine sand. The subsoil extends to a depth of about 15 inches and is dark yellowish-brown and dark-brown to brown, loose loamy fine sand. The underlying material is yellowish-brown and light brownish-yellow, loose fine sand. A few, very thin, dark-brown horizontal clay-iron bands of loamy fine sand occur below a depth of 30 inches.

Chelsea soils have a very low available moisture holding capacity and are rapidly permeable. The surface layer and, if present, the subsurface layer, are slightly acid to medium acid, and the subsoil and underlying material are normally medium acid to strongly acid. These soils are very low in available nitrogen, very low to

low in available phosphorus, and very low in available potassium. They are not suited to row crops.

Typical profile of a Chelsea loamy fine sand, 580 feet west and 300 feet south of the northeast corner of the SW¼, section 14, T. 75 N., R. 13 W., on north-facing convex side slope of 11 percent:

A—0 to 3 inches, dark grayish-brown (10YR 4/2) and dark-brown (10YR 4/3) loamy fine sand; single grain (structureless); very friable; slightly acid; clear, smooth boundary.

B—3 to 15 inches, dark yellowish-brown (10YR 4/4) and brown (10YR 4/3) loamy fine sand, dominantly dark yellowish brown but 10 percent dark brown to brown; single grain (structureless); loose; medium acid; clear, smooth boundary.

C1—15 to 35 inches, yellowish-brown (10YR 5/6) fine sand; single grain (structureless); loose; medium acid; gradual, smooth boundary.

C2—35 to 54 inches, light brownish-yellow (10YR 6/4) to yellowish-brown (10YR 5/6) fine sand; single grain (structureless); loose; discontinuous, dark-brown (7.5YR 4/4) quarter-inch horizontal clay-iron bands at 35 inches and half-inch bands at 4- to 8-inch intervals below 40 inches; medium acid.

Where Chelsea soils are not eroded, the A1 horizon ranges from 2 to 6 inches in thickness and from very dark grayish brown to dark grayish brown in color. In places a thin grayish A2 horizon occurs, but in many places it is mixed into the Ap horizon and is not discernible. The B horizon is dark yellowish brown to yellowish brown in some places. It is sand or loamy fine sand in most places. Thin, wavy, discontinuous clay-iron bands occur below a depth of about 25 inches. These bands are dark brown or brown in color and sand to loamy fine sand in texture. They commonly contain more clay and iron than the material between them. The solum generally ranges from medium acid to strongly acid in its most acid part but is slightly acid in some places.

Chelsea soils are lighter colored, have a thinner surface layer, and, in most places, are more acid than Sparta soils. Chelsea soils typically are more sandy to a depth of 40 inches or more than the Lamont soils and have a less developed, more sandy subsoil.

Chelsea loamy fine sand, 9 to 18 percent slopes (CaE).—This excessively drained, rapidly permeable soil occurs throughout the county on upland ridgetops and side slopes adjacent to the major stream valleys. The largest areas are hilly and occur on the south side of the Skunk River. Slopes are irregular and complex in many places, and blowouts are common on or near the ridgetops. This soil is closely associated with the Lamont, Clinton, Lindley, and Boone soils.

Included with this soil in mapping are soils that have a thin yellowish-brown surface layer. In most places this soil is in permanent vegetation, either grass or trees. It is not suited to cultivated crops. Its best use in Keokuk County is probably for trees or as a wildlife habitat. Where this soil is seeded to grass, the grass grows poorly and is easily overgrazed. A drought-tolerant species should be seeded.

The hazards of soil blowing and water erosion are very severe in exposed areas. Because natural fertility, organic-matter content, and available moisture capacity are low, stands of trees, grasses, or legumes, are difficult to establish. (Capability unit VIIs-1; woodland suitability group 5)

Chequest Series

The Chequest series consists of nearly level soils on the bottom lands of the major streams throughout the county. These soils developed from silty alluvium under native grasses and trees tolerant of excess wetness. They are moderately dark colored, poorly drained, and strongly acid. Chequest soils are closely associated with the Colo, Zook, Vesser, and Wabash soils.

In a typical profile the surface layer is silty clay loam and about 14 inches thick. It is very dark grayish brown and very dark gray in the upper 9 inches. The lower part is very dark grayish brown, dark grayish brown, and very dark gray and has some brownish mottles. To a depth of 38 inches, the subsoil is friable and firm silty clay loam that is dark grayish brown in the upper part, dark gray to very dark gray in the middle, and gray to dark gray in the lower part. Below this is dark-gray, firm light silty clay that extends to a depth of 56 inches. The subsoil has brownish mottles throughout.

Chequest soils have a high available moisture holding capacity and moderately slow permeability. The surface layer typically is medium acid, the subsoil is strongly acid to medium acid, and in some places the substratum is nearly neutral at a depth of about 40 inches. These soils normally are low in available nitrogen, medium in available phosphorus, and very low in available potassium.

Typical profile of Chequest silty clay loam, 2,040 feet east and 220 feet south of the northwest corner of section 10, T. 74 N., R. 11 W., on the nearly level flood plain of the South Skunk River:

Ap—0 to 9 inches, light silty clay loam that has very dark gray (10YR 3/1) ped exteriors and very dark grayish-brown (10YR 3/2) ped interiors; dark gray (10YR 4/1) when dry; very dark gray (10YR 3/1) when kneaded; weak, fine, subangular blocky structure that breaks to moderate, fine, granular structure; friable; few, fine, soft concretions of a strong-brown oxide; medium acid; abrupt, smooth boundary.

A3—9 to 14 inches, light silty clay loam that has very dark gray (10YR 3/1) ped exteriors and very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) ped interiors; very dark grayish brown (10YR 3/2) when kneaded; common, fine, faint mottles of dark yellowish brown (10YR 4/4) and strong brown (7.5YR 5/6); weak, fine, subangular blocky and moderate, very fine, subangular blocky structure; friable to firm; many, fine, soft concretions of a strong-brown oxide; few, fine, moderately hard concretions of a black oxide; strongly acid; clear, smooth boundary.

B1—14 to 18 inches, dark grayish-brown (10YR 4/2) medium silty clay loam, very dark grayish brown (10YR 3/2) when kneaded; common, fine, faint mottles of dark brown to brown (10YR 4/3) and yellowish brown (10YR 5/6); weak, fine, subangular blocky and moderate, very fine, subangular blocky structure; friable to firm; very few, thin, discontinuous clay films; many, fine, soft concretions of a strong-brown oxide; few, fine and medium (3 to 4 millimeters), moderately hard concretions of a strong-brown oxide and fine, moderately hard concretions of a black oxide; few, distinct, discontinuous grainy coats that are light gray (10YR 7/1) when dry; strongly acid; clear, smooth boundary.

B21tg—18 to 25 inches, dark-gray (10YR 4/1) to very dark gray (10YR 3/1) heavy silty clay loam, dark gray (10YR 4/1) when kneaded; common, fine, faint mottles of grayish brown (10YR 5/2) and few, fine, distinct mottles of strong brown (7.5YR 5/6); weak, medium, prismatic structure that breaks to moderate, fine and very fine, subangular blocky structure; firm; few, thin, discontinuous clay films; few, fine, soft-brown concretions of an oxide; distinct, discontinuous, grainy coats that are white (10YR 8/1) when dry; strongly acid; clear, smooth boundary.

B22tg—25 to 38 inches, heavy silty clay loam that has dark-gray (5Y 4/1) ped exteriors and gray (5Y 5/1) ped interiors; dark gray (5Y 4/1) when kneaded; common, fine, distinct mottles of dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6); weak, medium, prismatic structure that breaks to moderate, fine, subangular blocky structure; firm; few, thin, continuous clay films; few, fine, soft concretions of a strong-brown oxide and few, fine, moderately hard concretions of a black oxide; strongly acid; gradual, smooth boundary.

B31tg—38 to 56 inches, dark-gray (5Y 4/1) light silty clay; few, fine, distinct mottles of dark yellowish brown (10YR 4/4) and very few, fine, distinct mottles of yellowish brown (10YR 5/6); weak, medium, prismatic structure; firm; common, thin, continuous clay films; few, thin, very dark gray clay fills in old root channels; few, fine, soft concretions of a strong-brown oxide and few, fine, moderately hard concretions of a black oxide; neutral; gradual, smooth boundary.

The A horizon of the Chequest soils ranges from heavy silt loam to light silty clay loam. It is 12 to 20 inches thick. The upper part of the B horizon ranges from very dark gray or grayish brown to gray. Texture is medium or heavy silty clay loam in the upper part. The lower part of the B horizon is a dark-gray and gray, firm, silty clay loam or light silty clay. Mottles of dark yellowish brown, yellowish brown, and strong brown are distinctly evident in the subsoil. Chequest soils range from strongly acid to very strongly acid in the most acid part.

Chequest soils are not so clayey in the subsoil as are the Zook and Wabash soils nor as dark colored below a depth of 24 inches. Chequest soils have about the same clay content as the Colo soils but are more acid and are lighter colored when moist or dry. Chequest soils have more clay in the surface layer than Vesser soils, to a depth of 36 inches or more, and lack a distinct, thick, grayish subsurface layer typical for the Vesser soils.

Chequest silt loam, overwash (Cb).—The surface layer of this soil is 6 to 20 inches thick and consists of dark grayish-brown heavy silt loam overwash, but in other respects the profile of this soil is similar to the one described as typical for the series. Slopes range from 0 to 2 percent. The overwash has been deposited by runoff by the floodwaters of streams. This soil is poorly drained and moderately slow in permeability. It occurs throughout the county on first bottoms, where it is closely associated with Radford, Colo, Wabash, and Amana soils.

Included with this soil in mapping are some areas that have a thicker overwash layer and some areas where the overwash is silty clay loam.

This moderately fertile soil is used intensively for corn and soybeans. In most places the silty overwash improves tilth and makes the soil more easy to work. Since this soil is normally acid, it may need additions of lime. Also needed is supplemental drainage. Tile is used where outlets can be established, but some areas require open ditches. Overflow is a hazard on this soil, especially on bottom lands along the Skunk River. (Capability unit IIw–1; woodland suitability group 10)

Chequest silty clay loam (Cc).—This soil has a very dark gray to very dark grayish-brown surface layer 12 to 20 inches thick. The subsoil is silty clay loam mottled with brown, yellowish brown, strong brown, and grayish brown. This soil occurs on nearly level first bottoms throughout the county, in close association with Colo, Wabash, and Amana soils.

This soil is moderately fertile and is acid unless recently limed. It is moderately slow in permeability.

Included with this soil in mapping are some areas of similar soils that have a heavy silt loam surface layer and some areas that have a thin layer of lighter colored overwash.

This Chequest soil is suited to corn and soybeans. Although tilth is difficult to maintain in many places, this soil is used intensively for row crops. Overflow is a hazard, especially on bottom lands along the Skunk River, and supplemental drainage is needed. Tile drains are suitable where outlets can be established; other areas require open ditches. (Capability unit IIw–1; woodland suitability group 10)

Clarinda Series

The Clarinda series consists of poorly drained soils that have a dark-colored surface layer. These soils developed from very firm, gray clay subsoils that formed in earlier geological periods. The gray clay commonly is called gumbotil. The buried, clayey soils formed from weathered glacial till and are covered by loess in most places. Clarinda soils are on convex slopes of 5 to 14 percent that form the coves of drainageways or are in bands or strips at the shoulder of side slopes. Clarinda soils lie downslope from the loess-derived Otley soils and upslope from the till-derived Shelby soils.

In a typical profile the surface layer, about 11 inches thick, is very dark brown and very dark gray silty clay loam. The subsoil extends to a depth of 59 inches and is brownish and grayish, firm and very firm silty clay. Some brownish mottles are present.

Clarinda soils are very slowly permeable and have a high available moisture holding capacity. The surface layer is neutral to slightly acid. The subsoil is medium acid to slightly acid in the upper part and neutral to slightly acid in the lower part. These soils are low to very low in available nitrogen and very low in available phosphorus and available potassium.

Typical profile of Clarinda silty clay loam, 600 feet east and 50 feet north of the southwest corner of section 26, T. 77 N., R. 12 W., on a slope of 7 percent that faces north:

A1—0 to 11 inches, light silty clay loam that has very dark gray (10YR 3/1) ped exteriors and very dark brown (10YR 2/2) ped interiors; very dark brown (10YR 2/2) when kneaded; few, fine, faint mottles of dark brown (10YR 3/3); weak, very fine, subangular blocky and moderately fine granular structure; firm; few, fine, soft concretions of a strong-brown oxide; neutral; clear, smooth boundary.

IIB1—11 to 17 inches, light silty clay that has very dark grayish-brown (10YR 3/2) ped exteriors and dominantly dark grayish-brown (10YR 4/2) ped interiors; dark grayish brown (10YR 4/2) when kneaded; common, fine, faint mottles of brown (10YR 4/3) and yellowish red (5YR 4/6); moderate, very fine, subangular blocky structure; firm; few, thin and medium, discontinuous clay films; few, fine, soft concretions of a strong-brown oxide and few, fine and medium, moderately hard concretions of a black oxide; medium acid; clear, smooth boundary.

IIB21tg—17 to 30 inches, silty clay that is dark grayish brown (2.5Y 4/2) in the upper part and grades to dark gray (10YR 4/1) with depth; common, fine, distinct mottles of strong brown (7.5YR 5/6) and common, fine, prominent mottles of red (2.5YR 5/6); weak, medium, prismatic structure that breaks to moderate, very fine, subangular blocky structure; very firm; continuous, thin to medium clay films; many, fine,

soft concretions of a strong-brown or reddish-brown oxide and few, fine and medium, moderately hard concretions of a black oxide; few, clear quartz grains; medium acid; clear, smooth boundary.

IIB22tg—30 to 52 inches, gray (5Y 6/1) and light olive-gray (5Y 6/2) silty clay; common, fine, distinct mottles of light olive brown (2.5Y 5/4) and few, fine, prominent mottles of strong brown (7.5YR 5/8); weak, medium, prismatic structure that breaks to moderate, fine and very fine, subangular blocky structure; very firm; common, thin to medium, continuous clay films; few, fine, soft concretions of strong-brown and black oxides; few sand and clear quartz grains; neutral; clear, smooth boundary.

IIB23tg—52 to 59 inches, gray (5Y 6/1) medium silty clay; common, fine, prominent mottles of strong brown (7.5YR 5/8) and yellowish brown (10YR 5/8); weak, medium, prismatic structure that breaks to moderate, medium, subangular blocky structure; very firm; common, thin, discontinuous clay films; few, fine, soft concretions of a strong-brown oxide; common, clear quartz grains; neutral.

The A horizon dominantly is very dark gray, but it ranges to very dark brown or very dark grayish brown in cultivated areas. It is silty clay loam in most places but ranges to silt loam. The maximum content of clay of the paleo B (IIB) horizon ranges from 50 to 65 percent. The sand grains in this horizon typically increase in size and abundance with depth. The IIB horizon ranges from 2 to 8 feet in thickness. In places strong-brown and yellowish-brown mottles are throughout the B horizon. These soils generally are medium acid in the most acid part of the profile, but in some places the Clarinda soils are resaturated and are slightly acid or neutral.

Clarinda soils are more slowly permeable than the Shelby soils, have a grayer subsoil and substratum, and have a higher clay content in the subsoil. Clarinda soils have a thicker clayey, gray subsoil than the Lamoni soils. The Clarinda soils contain less sand and are grayer than the Adair soils.

Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded (CdC2).—This soil generally has a very dark grayish-brown silty clay loam plow layer 5 to 7 inches thick. This layer is mainly the remaining surface layer into which some subsoil material has been mixed by tillage. The subsoil is a very slowly permeable, very firm, gray to olive-gray silty clay 3 to 6 feet thick.

This soil normally occurs at the heads of drainageways that extend into broad, flat uplands, or it is in bands or strips just below the loess-till contact line. A few areas are on the ends of rounded ridges. This soil occurs below the moderately sloping loess-derived Otley and Ladoga soils, above Adair and Lamoni soils on side slopes, and above Colo-Ely silty clay loams, 2 to 6 percent slopes, in narrow drainageways.

This soil is very slowly permeable. It stays wet for longer periods than adjacent soils. Tilth normally is poor, and tillage is difficult. When this soil dries, its surface becomes hard and cloddy, and as drying continues, cracks appear at the surface and extend into the subsoil.

Included with this soil in mapping are small severely eroded areas where erosion has removed the surface layer and has exposed the silty clay or clay subsoil. Also included are a few areas that have a deeper, darker, and more friable surface layer than this soil. Other inclusions are small areas of Colo-Ely silty clay loams, 2 to 5 percent slopes, in narrow drainageways.

This soil is better suited to hay and pasture than to row crops, but it generally is used for row crops. This is because land use, in many places, is determined by that of adjacent soils. A few areas are in pasture. Crops grow poorly on this soil and are often yellow and stunted.

Where this soil is cultivated, it should be protected by terraces, tiled on the contour, and kept in meadow at least half of the time. Because of the silty clay or clay subsoil, this soil is not well suited to terraces and cuts should be kept to a minimum. If possible, terraces should be constructed above or below this soil. Severely eroded areas should be kept in permanent vegetation, such as birdsfoot trefoil. Topdressing with barnyard manure is beneficial on severely eroded areas. Seepage and surface wetness can be reduced by placing interceptor tile drains in the more permeable loessal soils upslope. (Capability unit IIIe–2; woodland suitability group 8)

Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded (CdD2).—This soil is similar to Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded, but it is more sloping and has a subsoil of very firm, gray and olive-gray clay 3 to 5 feet thick. It occurs in narrow bands or strips in a contour pattern just below the loess-till contact on side slopes, and it extends around the heads of drainageways. It generally is below the Otley and Ladoga soils, which are not so wet as this soil. It is above the Adair, Lamont, Gara, or Shelby soils on side slopes and above Colo-Ely silty clay loams, 2 to 5 percent slopes, in drainageways.

This soil is very slowly permeable. It stays wet for longer periods than adjacent soils. It is low in organic-matter content and has poor tilth. When this soil dries, its surface becomes hard and cloddy. By summer cracks appear at the surface and, as the soil continues to dry, extend into the subsoil.

Included with this soil in mapping are small areas of Colo-Ely silty clay loams, 2 to 5 percent slopes, in narrow drainageways. Also included are areas around the narrow drainageways and rounded areas between waterways, where the surface layer is thinner than typical and the clay subsoil is exposed in places.

This soil is used for row crops or pasture, though it is very poorly suited to row crops. It is moderately well suited to hay and pasture, but cultivated crops often are yellow or stunted. Most legumes do not grow well, but birdsfoot trefoil is suitable if this soil is adequately limed and ample phosphate is added. Where this soil is cultivated it should be protected by terraces, tilled on the contour, and kept in meadow crops much of the time.

Tilth can be improved by adding manure and by growing more meadow crops. Since this soil is poorly suited to terraces, they should be constructed in the soils above or below this Clarinda soil. An interceptor tile drain placed just above seeps, and in adjacent Otley and Ladoga soils upslope, reduces seepage and enables this soil to dry more quickly. The tile does not work properly if it is placed directly in the Clarinda soil. (Capability unit IVe–2; woodland suitability group 8)

Clinton Series

The Clinton series consists of moderately well drained soils that developed under a native vegetation of trees. These soils formed in loess that has a very low content of sand. Clinton soils are on convex ridgetops and side slopes of 2 to 18 percent on uplands and high benches along major streams. In some places they occur in complexes with Lamont and Chelsea soils.

In a typical profile about half an inch of decomposed litter and fine stems is on the surface. The surface layer, about 2 inches thick, is very dark gray silt loam. The subsurface layer is silt loam about 13 inches thick and is dark grayish brown in the upper 7 inches and dark brown to brown below. It is distinctly light colored when dry. The subsoil, which extends to a depth of 72 inches, is firm silty clay loam. It is dark yellowish brown in the upper part, dark brown to brown in the middle, and yellowish brown in the lower part. A few olive-gray and strong-brown mottles are present in the lower part. The underlying material is mottled yellowish-brown, firm silty clay loam.

Clinton soils have a high available moisture holding capacity and moderately slow permeability. The surface layer typically is slightly acid. The subsurface layer and subsoil are medium acid to strongly acid, and the underlying material is slightly acid to neutral. Clinton soils are low in organic-matter content. They are low in available nitrogen, medium to high in available phosphorus, and low in available potassium.

Typical profile of Clinton silt loam, 72 feet west and 125 feet south of the northeast corner of the SE¼SE¼ of section 7, T. 74 N., R. 12 W., on a convex ridgetop that has a slope of 3 percent that faces south:

O1—½ inch to 0, decomposed litter and fine stems.

A1—0 to 2 inches, very dark gray (10YR 3/1) medium silt loam, gray (10YR 5/1) when dry; moderate, very fine, granular structure; very friable; slightly acid; abrupt, smooth boundary.

A21—2 to 9 inches, dark grayish-brown (10YR 4/2) medium silt loam, light grayish brown (10YR 6/2) when dry; few, fine, dark yellowish-brown (10YR 4/4) mottles; moderate, thin, platy structure; very friable; slightly acid; abrupt, smooth boundary.

A22—9 to 15 inches, dark-brown to brown (10YR 4/3) heavy silt loam, light gray (10YR 7/1) when dry; weak, fine, subangular blocky structure; friable; abundant roots; many fine pores; very few, very fine concretions of a dark oxide; distinct, grainy coatings on all ped surfaces; medium acid; clear, smooth boundary.

B21t—15 to 27 inches, dark yellowish-brown (10YR 4/4) medium to heavy silty clay loam; strong, fine, subangular blocky structure; firm; few fine pores; patchy clay films on peds; few, light-gray (10YR 7/1), grainy coats when dry; very few, very fine concretions of a dark oxide; strongly acid; gradual, smooth boundary.

B22t—27 to 47 inches, silty clay loam that has dark-brown (10YR 4/3) ped exteriors and brown (10YR 5/3) ped interiors; heavy in upper part and medium in lower part; weak, medium, prismatic structure that breaks to strong, medium to fine, angular blocky structure; firm; distinct clay films on all peds; few, very fine concretions of a dark oxide; distinct, brown (10YR 5/3) coarse silt in crevices and on horizontal faces; medium acid; diffuse, smooth boundary.

B31t—47 to 72 inches, yellowish-brown (10YR 5/4) medium silty clay loam; few, very fine, distinct mottles of olive gray (5Y 5/2) and few, fine, distinct mottles of strong brown (7.5YR 5/6); weak, medium, prismatic structure that breaks to weak to moderate, medium, angular blocky structure; firm; brown (10YR 4/3), thin, discontinuous clay films on most peds; few, fine concretions of a dark oxide; medium acid; diffuse, smooth boundary.

C—72 to 84 inches, yellowish-brown (10YR 5/4) light silty clay loam; very few, very fine, distinct mottles of olive gray (5Y 5/2) and few, fine, faint mottles of yellowish brown (10YR 5/8); massive; some vertical cleavage; firm; very few dark-brown (10YR 4/3) fillings in old channels; slightly acid.

The A1 horizon ranges from 1 to 6 inches in thickness. Where this horizon is thin, it is very dark gray, but it ranges to dark grayish brown in its thicker parts. In uneroded areas, the A2 layers range from dark grayish brown to brown in color and from 2 to 8 inches in thickness. The B horizon ranges from medium silty clay loam to very light silty clay. Grayish mottles typically occur below a depth of 30 inches and increase in abundance with increasing depth. The solum is medium acid to strongly acid in the most acid part and is leached to a depth of 60 inches or more.

Clinton soils have a less distinct grayish subsurface layer than the somewhat poorly drained Keomah soils, which are not mottled in the upper part of the subsoil. Clinton soils have a thinner or lighter colored surface layer than the closely associated Ladoga soils.

Clinton silt loam, 2 to 5 percent slopes (ClB).—The surface layer of this soil is very dark gray and 2 to 6 inches thick. The subsurface layer, 4 to 8 inches thick, is a dark grayish-brown and dark-brown silt loam. In some places there is a very dark grayish-brown to brown plow layer that is 6 to 8 inches thick and consists of mixed material of the surface layer and the subsurface layer. The subsoil is brown to yellowish-brown silty clay loam to light silty clay. This soil has the profile described as typical for the series.

This soil occurs on narrow upland divides and side slopes. It is below the somewhat poorly drained Keomah soils and generally above moderately sloping Clinton soils. A few areas are above the Keswick soils, Radford-Ely complex, 2 to 5 percent slopes, or Nodaway-Martinsburg silt loams, 2 to 5 percent slopes. Where this soil extends to the broader, more nearly level ridgetops it occurs, in many places, with Givin soils and the gently sloping Ladoga soils.

This soil is moderately slowly permeable and low in organic-matter content. It is acid in areas not recently limed. The hazard of erosion is slight.

This soil is used intensively for row crops, but small acreages are in timber or permanent pasture. It is well suited to corn, soybeans, small grains, forage grasses, and legumes. Crops grow well. If tilth becomes poor, a meadow crop should be grown for an additional year. (Capability unit IIe-1; woodland suitability group 1)

Clinton silt loam, 5 to 9 percent slopes (ClC).—This soil has slightly thinner surface and subsurface layers than those in the profile described as typical for the series.

The surface layer is very dark gray and 2 to 4 inches thick. The subsurface layer is dark grayish brown and dark brown and 4 to 6 inches thick. The subsoil is brown to yellowish-brown silty clay loam to light silty clay.

This soil occurs on side slopes and narrow upland ridgetops that extend into irregular, steep uplands. It normally is below the gently sloping Clinton soils and above the strongly sloping Clinton, Keswick, and Lindley soils, and above Radford-Ely complex, 2 to 5 percent slopes, and Nodaway-Martinsburg silt loams, 2 to 5 percent slopes. Some areas that border the broader upland divides occur below gently sloping Ladoga soils or are in a complex with Lamont and Chelsea soils.

This soil is moderately well drained and moderately slowly permeable. It has low organic-matter content and is moderately susceptible to erosion.

Included with this soil in mapping are small areas of soils that have a thicker, darker surface layer and occur in narrow drainageways.

This Clinton soil is used for row crops and permanent pasture, but many areas are in trees. Where the soil is terraced, it is well suited to row crops. This soil is also suited to small grains and hay.

Tilth generally is not a concern where the present surface layer is maintained. If tilth becomes poor, meadow crops are increased or manure is added. Since this soil is normally acid, additions of lime are needed for good crop growth. (Capability unit IIIe–1; woodland suitability group 1)

Clinton silt loam, 5 to 9 percent slopes, moderately eroded (ClC2).—This soil has a thinner, lighter colored surface layer than that in the profile described as typical for the series. The plow layer is very dark grayish brown and 6 to 8 inches thick. It consists of the remaining parts of the surface and subsurface layers mixed by tillage with some material from the subsoil. The subsoil is brown to yellowish-brown silty clay loam to light silty clay loam. It is moderately slow in permeability.

This soil occurs on side slopes and on narrow, rounded upland ridgetops that extend into irregular, steep uplands. It generally occurs below the gently sloping Clinton soils and above the strongly sloping Clinton, Keswick, and Lindley soils and above Radford-Ely complex, 2 to 5 percent slopes, and Nodaway-Martinsburg silt loams, 2 to 5 percent slopes.

Included in mapping are small areas of a soil that has a thicker, darker surface layer that this Clinton soil. These included areas are in very narrow waterways. Also included, at the heads of drainageways, are small areas that are somewhat wet and seepy during wet periods.

This soil is used for row crops in most places, but small areas are in permanent pasture. If this soil is terraced, it is well suited to row crops. This soil is also suited to small grains and hay.

Management is needed on this soil to increase organic-matter content and to control erosion. Tilth can be improved by adding manure or by growing more meadow crops. Additions of lime are beneficial. (Capability unit IIIe–1; woodland suitability group 1)

Clinton silt loam, 9 to 14 percent slopes (ClD).—This soil has a thinner surface and subsurface layer than Clinton silt loam, 5 to 9 percent slopes.

The very dark gray surface layer usually is 1 to 3 inches thick, and the subsurface layer is 2 to 4 inches thick. In tilled areas, it has a very dark grayish-brown plow layer 6 to 8 inches thick. This soil is moderately well drained and has a severe erosion hazard.

This soil occurs at the crest of narrow ridges and in bands around strong side slopes. It lies downslope from moderately sloping Clinton soils and upslope from Lindley and Keswick soils, Radford-Ely complex, 2 to 5 percent slopes, or Nodaway-Martinsburg silt loams, 2 to 5 percent slopes. It is sometimes in a complex with Lamont and Chelsea soils.

Many small areas of wind-deposited sand are included with this soil in mapping and are shown on the map by the symbol for sand. Also included, in narrow waterways that extend into the side slopes, are soils that have a deeper and darker surface layer than this Clinton silt loam.

Most of this soil is in timber or permanent pasture. A few areas are cultivated. Where it is terraced or contoured to reduce erosion, this soil is suited to an occasional row crop.

Where this soil is exposed, the friable surface layer, strong slopes, and rapid runoff cause a severe hazard of erosion. Additions of lime are needed. (Capability unit IIIe–1; woodland suitability group 1)

Clinton silt loam, 9 to 14 percent slopes, moderately eroded (ClD2).—This soil is similar to Clinton silt loam, 9 to 14 percent slopes, except that it has a very dark grayish-brown to brown plow layer 6 to 8 inches thick. This layer consists of the surface and subsurface layers mixed with some subsoil by tillage.

This soil occurs on the crests of narrow ridges and in bands around strong side slopes. It is downslope from moderately sloping Clinton soils and upslope from Lindley and Keswick soils, Radford-Ely complex, 2 to 5 percent slopes, and Nodaway-Martinsburg silt loams, 2 to 5 percent slopes.

Included with this soil in mapping are some small areas of sand, some soils on stream benches, in narrow waterways that extend into the side slopes, and soils that have a deeper and darker surface layer than the Clinton silt loam. Plowing exposes subsoil material in some areas of the rounded crests and at the heads of drainageways.

Most of this soil is used for row crops. Some areas are in permanent pasture, and a few areas are in timber.

Because of the friable surface layer, strong slopes, and rapid runoff, erosion is a severe hazard on this Clinton soil. Where it is terraced or tilled on the contour to reduce erosion, this soil is suited to row crops. Additions of lime are needed. (Capability unit IIIe–1; woodland group 1)

Clinton silt loam, 14 to 18 percent slopes, moderately eroded (ClE2).—This soil has a very dark grayish-brown to brown plow layer 5 to 7 inches thick. It consists of the remaining parts of the surface and subsurface layers mixed with some subsoil by tillage. It has a very severe hazard of erosion.

This soil occurs on upland side slopes, usually below the moderately sloping or strongly sloping Clinton soils and above the soils of the bottoms or foot slopes. Some areas are above Lindley soils, Radford-Ely complex, 2 to 5 percent slopes, or Nodaway-Martinsburg silt loams, 2 to 5 percent slopes, or they may be associated with Chelsea and Lamont soils in a complex.

Included with this soil in mapping are areas of sand and of soils similar to Clinton silt loam that have a deeper and darker surface layer. Plowing has exposed the subsoil in some areas on rounded crests and at the heads of drainageways.

This soil is used for row crops in many places, but it is better suited to hay or improved permanent pasture. It is well suited to forage grasses and legumes. Since this soil is normally acid, additions of lime are beneficial. (Capability unit IVe–1; woodland suitability group 1)

Clinton silt loam, benches, 5 to 9 percent slopes, moderately eroded (CmC2).—This soil is similar to Clinton silt loam, 5 to 9 percent slopes, moderately eroded, except that it occurs on side slopes and benches adjacent to major stream bottoms instead of in the uplands. Some areas are on benches that break abruptly from the strongly sloping uplands. These benches are underlain by allu-

vium at a depth of 10 to 15 feet. This soil normally lies below the gently sloping Ladoga soil and above the bottoms or foot slopes.

Included with this soil in mapping are areas that have a surface layer similar to Clinton silt loam, 5 to 9 percent slopes, and areas that have a thicker and darker surface layer than is typical for Clinton soil. Also included are soils so severely eroded that the subsoil is exposed. These areas are shown on the map by the symbol for severe sheet erosion.

Most of this soil is in row crops, but small acreages are in permanent pasture or timber. Row crops can be grown without excess soil loss where the soil is terraced and tilled on the contour, but in many places the irregular slope pattern makes terracing and tilling difficult.

This soil must be carefully managed to maintain good tilth. Additions of manure or more meadow crops help to improve tilth. Additions of lime are needed. This soil normally is low in organic-matter content. (Capability unit IIIe-1; woodland suitability group 1)

Clinton soils, 5 to 9 percent slopes, severely eroded (CnC3).—These soils have a dark grayish-brown to brown or yellowish-brown plow layer 6 to 8 inches thick. This layer is a mixture of mostly subsoil but also a small amount of material from the surface and subsurface layers. Since the subsoil is exposed in most places, the surface is silt loam to silty clay loam and is in poor tilth.

These soils are on side slopes and narrow, rounded upland ridgetops that extend into irregular, steep uplands. They usually lie below the gently sloping Clinton soils and above strongly sloping Clinton, Keswick, and Lindley soils, Radford-Ely complex, 2 to 5 percent slopes, or Nodaway-Martinsburg silt loams, 2 to 5 percent slopes. Some areas that border the broader upland divides are below the gently sloping Ladoga soils, and other areas occur in a complex with Lamont and Chelsea soils.

Included with Clinton soils in mapping are small areas of wind-deposited sand and of some seasonally wet and seepy soils that have a gray subsoil. In the very narrow waterways, soils are included that have a deeper, darker surface layer than the Clinton soils.

These soils are mostly cultivated. They are poorly suited to row crops and better suited to hay or improved pasture. Where these soils are contoured or protected against further erosion in other ways, they can be used for row crops.

Because the silty clay loam subsoil is exposed in most places, these soils slowly take in water, have rapid runoff, and are severely susceptible to erosion. These soils benefit if lime is added. They are very low in organic-matter content. (Capability unit IIIe-1; woodland suitability group 1)

Clinton soils, 9 to 14 percent slopes, severely eroded (CnD3).—These soils have a dark grayish-brown to brown or yellowish-brown plow layer that is 6 to 8 inches thick. This layer is a mixture of mostly subsoil but also a small amount of material from the surface and subsurface layers. Since the subsoil is exposed in most places, the plow layer ranges from silt loam to silty clay loam.

These soils are on the crests of narrow ridges and in bands around strong side slopes. They lie downslope from moderately sloping Clinton soils and upslope from Lindley and Keswick soils, Radford-Ely complex, 2 to 5 percent slopes, and Nodaway-Martinsburg silt loams, 2 to 5 percent slopes, or they are associated in a complex with the Lamont and Chelsea soils.

Included with these soils in mapping are small areas of sand and, in the very narrow waterways, of soils that have a deeper and darker surface layer than these Clinton soils. Also included in some areas are soils that are seasonally seepy and have a gray subsoil.

Most areas of these severely eroded Clinton soils are cultivated. They are poorly suited to row crops but are well suited to hay and improved pasture.

These soils require good management to be productive. Tilth is poor, and a good seedbed preparation is difficult. Applying large amounts of barnyard manure, lime, and fertilizer, according to needs as determined by soil tests, raises the level of fertility. Because the silty clay subsoil is exposed in many places, water intake is slow, runoff is rapid, and the hazard of erosion is severe. These soils are very low in organic-matter content. (Capability unit IVe-1; woodland suitability group 1)

Clinton soils, 14 to 18 percent slopes, severely eroded (CnE3).—These soils have a dark grayish-brown to brown or yellowish-brown plow layer 5 to 7 inches thick. This layer is a mixture of mostly subsoil but of small amounts of material from the surface and subsurface layers. Since the subsoil is exposed in most places, the surface soil ranges from silt loam to silty clay loam.

These soils occur on upland side slopes, generally below the moderately sloping or strongly sloping Clinton soils and above the Lindley soils, Radford-Ely complex, 2 to 5 percent slopes, or Nodaway-Martinsburg silt loams, 2 to 5 percent slopes. In places they occur in a complex with Chelsea and Lamont soils.

Included with these soils in mapping are small areas of sand and, in the very narrow waterways that extend into the sidehills, of soils that have a deeper and darker surface layer than the Clinton soils.

Although these soils are better suited to hay or pasture, they occasionally are used for row crops. These soils respond to application of lime. (Capability unit VIe-1; woodland suitability group 1)

Colo Series

The Colo series consists of poorly drained soils that developed in silty alluvium. The native vegetation was prairie grasses tolerant of excess wetness. These soils occur throughout the county. They are on nearly level first bottoms of major streams and their tributaries, on alluvial fans at the bases of some upland slopes, and in nearly level upland drainageways. In these drainageways, Colo soils occur in a complex with Ely soils. Slopes range from 0 to 5 percent but are mostly 2 percent or less.

In a typical profile the surface layer is very dark gray or black silty clay loam 42 inches thick. The subsoil is black, firm silty clay loam that has a few light olive-brown mottles below a depth of 56 inches.

Colo soils have high available moisture holding capacity and are moderately slow in permeability. They generally are slightly acid to depths of 40 inches or more. They normally are medium in available nitrogen and available phosphorus and low in available potassium.

Typical profile of Colo silty clay loam, 2,040 feet south and 1,390 feet west of the northeast corner of section

6, T. 77 N., R. 13 W., on a nearly level flood plain of the South English River:

Ap—0 to 8 inches, very dark gray (10YR 3/1) light silty clay loam, very dark gray (10YR 3/1) when kneaded; few, very fine, dark-brown to brown (7.5YR 4/4) mottles (associated with old roots); weak, cloddy structure breaking to weak, medium, subangular blocky structure; friable; slightly acid; abrupt, smooth boundary.

A11—8 to 16 inches, very dark gray (10YR 3/1) and black (10YR 2/1) light silty clay loam, very dark gray (10YR 3/1) when kneaded; few, fine, dark yellowish-brown (10YR 3/4) mottles; weak, fine, granular structure; firm; slightly acid; gradual, smooth boundary.

A12—16 to 32 inches, black (10YR 2/1) light to medium silty clay loam; weak, very fine, prismatic structure breaking to weak, very fine, subangular blocky and fine, granular structure; firm; slightly acid; gradual, smooth boundary.

A3—32 to 42 inches, black (10YR 2/1) medium silty clay loam; weak, very fine, prismatic breaking to weak, fine, subangular blocky structure; firm; slightly acid; gradual, smooth boundary.

B2g—42 to 56 inches, black (10YR 2/1) medium to heavy silty clay loam; weak, fine, prismatic breaking to weak, very fine, subangular blocky structure; firm; few shiny ped faces (clay films or pressure faces); very few, fine, hard concretions of a reddish-brown oxide; neutral; gradual, smooth boundary.

B3—56 to 72 inches, black (10YR 2/1), same when kneaded, medium to heavy silty clay loam; few, fine, distinct mottles of light olive brown (2.5Y 5/4); very weak, fine, prismatic structure; firm; slightly acid.

The thickness of the black part of the profile is more than 36 inches. The content of clay in the surface layer and subsoil averages about 30 to 35 percent and is about 36 percent at the maximum. In some places a few yellowish-brown or olive-brown mottles occur below a depth of 36 to 40 inches. The solum is slightly acid in the most acid part and is leached of carbonates to a depth of 6 feet or more.

Colo soils are less acid than the Chequest soils and have a much thicker, darker colored surface layer and subsoil. They have a lower content of clay in the subsoil than the Zook and Wabash soils.

Colo silt loam, overwash (Co).—The surface layer is very dark gray to dark-gray silt loam 6 to 20 inches thick that has been recently deposited on silty clay loam. The sediments forming this layer were deposited by the floodwaters of adjacent rivers and creeks, or they were washed from small secondary drains in the uplands. These overwash sediments are more friable, lighter colored, and more easily tilled than the original surface layer. The surface layer of Colo silt loam, overwash, is moderately permeable, but the black subsoil is slowly permeable.

This soil occurs on first bottoms of major streams and tributaries throughout the county. Slopes are 0 to 2 percent. Small areas of this soil occur near the base of upland slopes below the Judson and Ely soils, where small upland drains have deposited sediments upon the flood plains of larger streams. Other areas are on first bottoms in close association with Radford, Wabash, and Chequest soils.

Although this soil is occasionally flooded, nearly all of it is used for row crops, generally corn or soybeans. Row crops are moderately well suited to well suited in drained areas. Organic-matter content is medium to low, and tilth generally is good. Where tilth is poor, a meadow crop can be seeded. (Capability unit IIw-1; woodland suitability group 10)

Colo silty clay loam (0 to 2 percent slopes) (Cs).—This soil has a very dark gray and black surface layer more than 20 inches thick. Its profile is that described as typical for the series. Colo silty clay loam occurs on first bottoms of major streams and tributaries in close association with Chequest and Wabash soils. In many places this soil is along small streams in valleys 1/8 to 1/4 mile wide. In these narrow valleys, the soil is flooded frequently, and in some places adjacent to the streambanks, it is stratified with silt. In the wider valleys, this soil is adjacent to areas of Amana or Nodaway soils that parallel the stream channels.

Included with this soil in mapping are a few areas dissected by meandering channels. These channels are partly filled with sediment, but they cannot be crossed with farm machinery in most places. Also included in mapping are areas where the dark-colored material extends only to a depth of 24 to 30 inches.

Although occasionally flooded, this soil is used mainly for intensive row cropping. The more frequently flooded or inaccessible areas are in pasture. Where it is artificially drained and protected from flooding, this soil is well suited to row crops. The organic-matter content is high, and tilth is generally good. This soil generally dries out somewhat slowly in spring. Small additions of lime are beneficial. (Capability unit IIw-1; woodland suitability group 10)

Colo silty clay loam, 2 to 5 percent slopes (CsB).—This soil has a profile similar to the one described for the series. This soil occurs as narrow bands on foot slopes in all areas of the county. It normally lies below the Ely or Judson soils on foot slopes or below the Ladoga, Otley, Adair, or Gara soils of the uplands. It normally is above Colo, Wabash, or Amana soils of the first bottoms. Included with this soil in mapping are a few areas that have a lighter colored, more silty surface layer and areas where the dark colors extend to depths of only 24 inches.

This soil is used intensively for row crops and is well suited to growing corn and soybeans. Organic-matter content is high, and tilth usually is good. Since the soil dries somewhat slowly in spring, tillage should be delayed until the moisture content is favorable.

This soil is poorly drained and requires tile drainage. Where runoff water is received from nearby uplands, diversion terraces are beneficial. These terraces are constructed at the base of the upland slopes. (Capability unit IIw-3; woodland suitability group 10)

Colo-Ely silty clay loams, 2 to 5 percent slopes (CtB).—These soils are closely intermingled in narrow upland drainageways. The Colo soils lie adjacent to streams and in many places have up to 16 inches of recently deposited sediment on the surface. They are cut by channels and gullies that, in many places, cannot be crossed with farm machinery. The Ely soils are in fairly uniform bands at the base of slopes. The largest acreages of this complex occur in the rolling to steep areas of the county.

Colo silty clay loam and Ely silty clay loam, the dominant soils in this complex, have similar profiles to those described under their respective series. The Colo soils are black throughout and are poorly drained. The Ely soils have a black, very dark gray, or very dark brown surface layer and are somewhat poorly drained. Both kinds of soil have a high content of organic matter.

Included with these soils in mapping are areas of moderately well drained to well drained, dark-colored Judson soils and some well-drained soils that have a loam surface layer.

Most areas of this complex can be drained by tile lines. Runoff from the uplands can be controlled by diversion terraces. In most areas, drainageways need to be kept in grass so as to prevent gullying. (Capability unit IIw-3; woodland suitability group 10)

Dickinson Series

The Dickinson series consists of somewhat excessively drained soils of the uplands. These soils developed from eolian sand or sands reworked by wind. The native vegetation was prairie grasses. These soils are on convex slopes of 2 to 14 percent in the northwestern part of the county. The most extensive areas of Dickinson soils are in the western part of Washington Township. In a few places, they are on high stream benches along the North and South Skunk Rivers. In Keokuk County, Dickinson soils occur closely in complexes with Sparta soils on stream benches and on ridgetops where slopes are 5 percent or less. They also occur closely with Sparta and Ladoga soils on side slopes of 5 to 14 percent.

In a typical profile the surface layer, about 13 inches thick, is very dark grayish-brown sandy loam and fine sandy loam. The subsoil extends to a depth of 56 inches. It is very friable and friable, dark-brown to brown and dark yellowish-brown fine sandy loam in the upper part. Below a depth of 44 inches, the subsoil is a very friable, yellowish-brown loamy fine sand. Pebbles do not occur.

Dickinson soils have a low available moisture holding capacity and moderately rapid to rapid permeability. The surface layer ranges from medium acid to neutral, the subsoil is medium acid to slightly acid, and the substratum typically is neutral. These soils are low to very low in available nitrogen, phosphorus, and potassium.

Typical profile of a Dickinson sandy loam, 600 feet east and 280 feet south of the northwest corner of the SE¼NW¼ section 22, T. 77 N., R. 12 W., on a convex side slope of 11 percent that faces south:

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) sandy loam, grayish brown (10YR 5/2) when dry; very friable; medium acid; abrupt, smooth boundary.

A1—6 to 13 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; few, fine, faint mottles of dark brown (10YR 3/3); weak, fine, subangular blocky structure that breaks to weak, fine, granular structure; very friable; medium acid; clear, smooth boundary.

B1—13 to 18 inches, fine sandy loam that has very dark grayish-brown (10YR 3/2) ped exteriors and dark brown (10YR 4/3) ped interiors; weak, fine, subangular blocky structure; very friable; medium acid; clear, smooth boundary.

B21t—18 to 24 inches, fine sandy loam that has brown (10YR 5/3) ped exteriors and yellowish-brown (10YR 5/4) ped interiors; weak, fine, subangular blocky structure; friable; thin, discontinuous, dark-brown (10YR 3/3) clay films; distinct, clear grains of quartz coat peds; slightly acid; clear, smooth boundary.

B22t—24 to 32 inches, fine sandy loam that has dark yellowish-brown (10YR 4/4) ped exteriors and yellowish-brown (10YR 5/6) ped interiors; weak, medium, subangular blocky structure; friable; thin, discontinuous, dark-brown (10YR 3/3) clay films; distinct, clear grains of quartz coat peds; slightly acid; clear, smooth boundary.

B31—32 to 44 inches, fine sandy loam that has dark yellowish-brown (10YR 4/4) ped exteriors and yellowish-brown (10YR 5/6) ped interiors; very weak, medium, subangular blocky structure; very friable; neutral; gradual, smooth boundary.

B32—44 to 56 inches, yellowish-brown (10YR 5/4) loamy fine sand; very weak, medium, subangular blocky structure; very friable; neutral.

The A1 horizon ranges from 10 to 15 inches in thickness and from very dark brown to very dark grayish brown. The B1 horizon ranges from very dark grayish brown to dark brown. The B2 horizon ranges from dark brown to yellowish brown. In places thin horizons of loam or light sandy clay loam occur in the profile. The B3 horizon ranges from sandy loam to loamy sand or sand. The solum is slightly acid to medium acid in its most acid part.

Dickinson soils have a less sandy subsoil than Sparta soils and are more sandy than Ladoga soils. The surface layer of Dickinson soils is thicker than that of Lamont soils, and the subsoil is less strongly developed. Dickinson soils lack the grayish subsurface layer that occurs in uneroded Lamont soils.

Dickinson-Sparta complex, 2 to 5 percent slopes (DhB).—The soils in this complex have a very dark grayish-brown or very dark brown surface layer 12 to 14 inches thick. These soils are somewhat excessively drained to excessively drained.

This complex occurs as slightly rounded ridges that generally extend from the northwest to the southeast. In the uplands the complex occupies sandy ridgetops that are slightly higher than the surrounding landscape. It is closely associated with the Dickinson-Sparta-Ladoga complex, with dark-colored Otley soils, and with moderately dark colored Ladoga soils. In some places, it is surrounded by areas of dark-colored Mahaska soils or of moderately dark colored Givin soils. The complex also occupies low stream terraces along the Skunk River.

Included with this complex in mapping are areas that have a surface layer of coarse sand and eroded areas in which yellowish-brown sand or sandy loam is exposed. In the uplands a few areas are included that have a very dark brown to brown loam surface layer that extends to a depth of 24 inches. Other inclusions in the uplands are a few areas of silty, more fertile soils.

The soils in this complex are mostly used for crops, but some areas are in timber or pasture. These soils normally occur as small areas within fields of other soils and are farmed with those soils. They should be tilled on the contour where possible to control soil losses. Unless rains are timely and evenly spaced, these soils are subject to drought. Small sand blowouts are common in cultivated areas. Because of the irregular slope pattern, terrace construction is difficult in these soils. Additions of lime are beneficial on these soils. (Capability unit IIIs-1; woodland suitability group 5)

Dickinson-Sparta-Ladoga complex, 5 to 9 percent slopes, moderately eroded (DlC2).—The Dickinson and Sparta soils in this complex are moderately permeable and somewhat excessively drained to excessively drained. They are sandy soils that have a dark grayish-brown or very dark brown surface layer 8 to 14 inches thick. The Ladoga soils are moderately well-drained and have moderately slow permeability. Their surface layer is very dark grayish-brown and 4 to 8 inches thick.

The soils of the complex occur on side slopes and on ridgetops that extend into more dissected topography. In these positions the soils are closely associated with Otley

and other Ladoga soils. This complex also occurs on rounded crests or on the side slopes of bench terraces, and in these positions the soils are closely associated with gently sloping and moderately sloping Ladoga or Otley soils. Alluvium underlies these benches at a depth of 10 to 15 feet.

A small area of this complex is in section 36 of Sigourney Township. Here the surface layer is dominantly sandy loam. In other areas the soils have a dark-colored loam surface layer. These areas are mostly near the northwest corner of Warren Township and in sections 13 and 14 of Prairie Township.

Included with these soils in mapping are a few, small, yellowish-brown, eroded areas, and in cultivated areas, small blowouts.

The soils in this complex are mainly in crops and pasture, but a few areas have scattered trees. These soils are moderately well suited to row crops, but they are better suited to forage crops and improved pasture. Where these soils are tilled on the contour, an occasional row crop can be grown without excess soil losses.

The soils in this complex generally are low to medium in fertility. Where cultivated, they are moderately susceptible to soil blowing and water erosion. The Dickinson and Sparta soils often are droughty.

Contour tilling and minimum tillage reduce the hazard of soil blowing and water erosion. Frequent additions of manure help to control erosion, improve fertility, and increase the water-holding capacity of the soil. The irregular slope pattern makes construction of terraces impractical. Additions of lime are beneficial. (Capability unit IIIs-1; woodland suitability group 5)

Dickinson-Sparta-Ladoga complex, 9 to 14 percent slopes, moderately eroded (DlD2).—Except for slope, this complex is similar to Dickinson-Sparta-Ladoga complex, 5 to 9 percent slopes, moderately eroded. It occurs on upland slopes and bench terraces and is closely associated with the Otley and other Ladoga soils and with Dickinson-Sparta-Ladoga complex, 5 to 9 percent slopes, moderately eroded, on the same benches.

Areas adjacent to the South English River in Adams and English River Townships have a dominantly sandy surface layer. Areas in Adams and Washington Townships have a dominantly loam surface layer. Included with this complex are a few areas of uneroded soils that have a deeper and darker surface layer and some eroded areas that are yellowish brown.

The soils in this complex generally are in crops or pasture. Where they are tilled on the contour, a row crop can be grown occasionally. Where they are cultivated, the soils in this complex should be tilled on the contour, but tillage should be kept to a minimum because erosion is a hazard.

Frequent additions of manure help control erosion, improve fertility, and increase the water-holding capacity of these soils. Additions of lime are beneficial. Since the slope pattern is irregular, terraces are difficult to construct. (Capability unit IVe-1; woodland suitability group 5)

Dunbarton Series

The soils of the Dunbarton series are moderately well drained. They developed from reddish, weathered, clayey limestone under a native vegetation of trees. In most places this residuum is overlain by 5 to 15 inches of medium-textured material (loess). These soils are on convex side slopes of 10 to 20 percent in areas adjacent to the major rivers.

In a typical profile the surface layer, about 5 inches thick, is dark grayish-brown silt loam. The subsoil, which extends to a depth of about 24 inches, is very firm clay. It is reddish brown in the upper 15 inches and yellowish red in the lower part. Some limestone fragments occur above the underlying material, which consists of unconsolidated limestone flagstones.

Dunbarton soils are very slowly permeable and have a low to moderate available moisture holding capacity. The surface layer is slightly acid, and the subsoil is neutral to slightly acid. These soils are very low in available nitrogen and phosphorus and low in available potassium.

Typical profile of Dunbarton silt loam, 1,300 feet east and 2,450 feet north of the southwest corner of section 8, T. 75 N., R. 13 W., on a side slope of 15 percent that faces north:

Ap—0 to 5 inches, dark grayish-brown (10YR 4/2) heavy silt loam, dark grayish brown (10YR 4/2) when kneaded; very few, fine, distinct mottles of strong brown (7.5YR 5/8); weak, fine, subangular blocky that breaks to moderate, fine, granular structure; friable; few, fine, soft concretions of a black oxide; slightly acid; abrupt boundary.

IIB21t—5 to 9 inches, clay that is reddish brown (5YR 4/4) mixed with some dark grayish brown (10YR 4/2); few, fine, faint mottles of yellowish red (5YR 4/6-5/6); strong, very fine, subangular blocky structure; firm; few, thin, discontinuous clay films; common, fine, soft concretions of a black oxide; few cherty fragments a quarter inch in diameter; neutral; clear, smooth boundary.

IIIB22t—9 to 15 inches, reddish-brown (5YR 4/4) clay; common, fine, faint mottles of yellowish red (5YR 5/8); strong, very fine, subangular blocky structure; very firm; common, thin, discontinuous clay films; few dark reddish-brown (5YR 2/2) clay fills in root channels; few, fine, soft concretions of a black oxide; decomposed limestone fragments; few fine sandstone fragments; neutral; clear, smooth boundary.

IIIB23t—15 to 19 inches, yellowish-red (5YR 5/8) clay; moderate, very fine, subangular blocky structure; very firm; very few, thin, discontinuous clay films; few dark reddish-brown (5YR 3/2) clay fills in root channels; few, fine, soft concretions of a black oxide; limestone fragments as much as 4 inches long; few decomposed sandstone fragments; neutral; gradual, smooth boundary.

IIIB3—19 to 24 inches, yellowish-red (5YR 5/6) clay; moderate, very fine, subangular blocky structure; few, fine, moderately hard concretions of black and strong-brown oxides; limestone fragments as much as 4 inches long; common decomposed sandstone fragments as much as an inch in diameter; neutral; abrupt, wavy boundary.

IIIC—24 inches +, unconsolidated limestone flagstones.

The A1 horizon ranges from very dark grayish brown to dark grayish brown in color and from 2 to 6 inches in thickness. The surface layer is generally silt loam to silty clay loam, but it is clay loam in areas not mantled with loess. The B horizon ranges from dark grayish brown to reddish brown or yellowish red in color and from clay to silty clay in texture. Fragments, as much as 4 inches in diameter, are in the B horizon. They are mostly of limestone, but a few are of sandstone. The solum is neutral or slightly acid in the most acid part. It is abruptly underlain by fractured limestone at a depth of about 15 to 30 inches.

Dunbarton soils are less acid in the subsoil than Gosport soils and are underlain by limestone rather than by silty clay shale. Dunbarton soils developed from weathered limestone and are underlain by limestone fragments, but Lindley soils developed from glacial till and are not underlain by limestone. Also, Dunbarton soils lack the glacial stones and pebbles that occur in the Lindley soils.

Dunbarton silt loam, 10 to 20 percent slopes, severely eroded (DuE3).—This soil is of minor extent and occurs mainly in the steep, strongly dissected areas adjacent to major streams. It normally is below strongly sloping Clinton soils and above Sogn soils or soils on foot slopes or first bottoms.

This soil generally has a dark grayish-brown silt loam plow layer 5 to 7 inches thick. The subsoil is dark grayish-brown to reddish-brown or yellowish-red clay that is firm and very slowly permeable. Unconsolidated limestone flagstones occur at a depth of 20 to 40 inches and are within the depth of normal cultivation in many places.

Included with this soil in mapping are a few areas of a soil that has a thicker surface layer and some that have a clay loam surface layer.

This Dunbarton soil is not suited to row crops, and it generally is used for hay crops and pasture. Some areas are in trees. Cropped areas probably are better suited to hay and to pasture than to row crops. Growth of plants is poor because the soils are shallow, low in fertility, and very low in organic-matter content. Most areas are in poor tilth, and limestone fragments interfere with plowing in many places. Because the hazard of erosion is severe, careful management is needed to control further erosion. (Capability unit VIIs-1; woodland suitability group 6)

Ely Series

The soils of the Ely series are somewhat poorly drained. They developed in silty alluvium under native grasses. These soils occur on nearly even to slightly concave alluvial fans and on foot slopes of 3 to 7 percent. In the narrow waterways, Ely soils are mapped in complexes with Colo soil and with Radford soils.

In a typical profile the surface layer, about 24 inches thick, is very dark brown, black, and very dark gray silty clay loam. The subsoil, which extends to a depth of 58 inches, is very dark gray, dark gray, and gray, friable silty clay loam in the upper part and grayish-brown, friable to firm silty clay loam at a depth of about 47 inches. The subsoil is mottled throughout. The underlying material is mottled gray and brown silty clay loam.

The Ely soils have a high available moisture holding capacity and are moderately permeable. These soils are generally acid unless recently limed. They are low to medium in available nitrogen and very low in available phosphorus and available potassium.

Typical profile of Ely silty clay loam, 320 feet south and 200 feet east of the northwest corner of the NE¼NE¼ section 20, T. 77 N., R. 12 W., on a convex foot slope of 3 percent that faces north:

Ap—0 to 8 inches, very dark brown (10YR 2/2) light silty clay loam, very dark brown (10YR 2/2) when kneaded; weak, fine, subangular blocky breaking to moderate, fine, granular structure; friable; slightly acid; abrupt, smooth boundary.

A1—8 to 15 inches, black (10YR 2/1) light silty clay loam, very dark brown (10YR 2/2) when kneaded; moderate, fine, granular structure; friable; medium acid; clear, smooth boundary.

A3—15 to 24 inches, very dark gray (10YR 3/1) light silty clay loam, very dark grayish brown (10YR 3/2) when kneaded; weak, fine, subangular blocky breaking to moderate, fine, granular structure; few, fine, faint mottles of dark grayish brown; friable; medium acid; clear, smooth boundary.

B1—24 to 32 inches, very dark gray (10YR 3/1) light silty clay loam; few, fine, faint mottles of dark grayish brown (10YR 4/2) and dark yellowish brown (10YR 3/4); moderate, fine and very fine, subangular blocky structure; friable; medium acid; gradual, smooth boundary.

B21—32 to 39 inches, light silty clay loam that feels gritty and has dark-gray (10YR 4/1) ped exteriors and dark grayish-brown (10YR 4/2) ped interiors; common, fine, faint mottles of dark brown (10YR 3/3) and few, fine, distinct mottles of yellowish brown (10YR 5/4); weak, medium, prismatic structure that breaks to weak, medium and fine, subangular blocky structure; friable; common, fine, tubular pores; few, fine, soft concretions of black iron and manganese; slightly acid; gradual, smooth boundary.

B22—39 to 47 inches, silty clay loam that feels gritty and has gray (10YR 5/1) ped exteriors and dark-brown (10YR 4/3) ped interiors; common, fine, distinct mottles of dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4); weak, medium, prismatic structure that breaks to weak, medium, subangular blocky structure; friable; common, fine, tubular pores; few, fine, soft concretions of black iron and manganese; slightly acid; gradual, smooth boundary.

B3—47 to 58 inches, grayish-brown (10YR 5/2) light silty clay loam; common, fine, distinct mottles of yellowish brown (10YR 5/4) and strong brown (7.5YR 5/6); weak, medium, prismatic structure that breaks to weak, medium, subangular blocky structure; friable to firm; few, fine, soft concretions of black iron and manganese and stains of dark brown; water table at 53 inches; neutral; gradual, smooth boundary.

C—58 to 65 inches, gray (10YR 5/1) and brown (10YR 5/3) light silty clay loam; common, fine, faint mottles of strong brown (7.5YR 5/6); massive (structureless); friable; many, fine, soft concretions and stains of dark reddish-brown iron and manganese; neutral.

The A horizon ranges from 15 to 30 inches in thickness. Its color ranges from black to very dark gray but also covers very dark brown. The dark color extends to a depth of 36 inches in places. The A horizon is silt loam or silty clay loam. The B horizon is mostly light silty clay loam, but is medium silty clay loam in places. It ranges from dark gray and gray to grayish brown and has many yellowish-brown or strong-brown mottles. Structure of the B horizon ranges from weak to moderate. The solum is medium acid in the most acid part. The content of sand in the profile generally ranges from 10 to 20 percent, depending on slope, but content typically is less than 15 percent in the upper horizons. Much of the sand is very fine.

Ely soils have a grayer, more mottled subsoil than Judson soils and a somewhat browner subsoil than Colo soils. Ely soils have a less developed subsoil than the Vesser soils, which have an A2 horizon.

Ely silty clay loam, 3 to 7 percent slopes (ElB).—This somewhat poorly drained soil has a black or very dark brown surface layer 15 to 30 inches thick. The subsoil generally is very dark gray to dark-gray silty clay loam and is moderately permeable. This soil occurs on foot slopes, closely associated with poorly drained Colo soils and moderately well drained to well drained Judson soils. It normally is below the more strongly sloping, loess-derived Otley or Ladoga soils of the uplands.

Included with this soil in mapping are small areas that have a gray subsurface layer and areas that are poorly

drained. These areas generally are near small waterways. Other small included areas are moderately well drained and occur on the upper slopes. They have a thinner surface layer than that of Ely silty clay loam, 3 to 7 percent slopes.

This Ely soil is well suited to intensive use for row crops. Corn, soybeans, small grains, forage grasses, and legumes normally grow well.

This soil is generally farmed with adjacent soils on first bottoms. It should be tilled on the contour. Where this soil joins the upland loess-derived soils, diversion terraces can be constructed to protect it from runoff. Some areas benefit from installation of tile drains. The organic-matter content of this soil is high, and tilth generally is good. These soils are acid, unless recently limed, and, additions of lime are beneficial. (Capability unit IIe-2; woodland suitability group 4)

Gara Series

The Gara series consists of moderately well drained, loamy soils that contain some stones and pebbles. These soils of the uplands developed from weathered glacial till under mixed prairie grasses and trees. They are on convex side slopes and narrow ridgetops adjacent to major streams. Slopes range from 9 to 25 percent.

In a typical profile the surface layer, about 6 inches thick, is very dark grayish-brown loam. Uneroded areas have about a 3-inch loam subsurface layer that is dark grayish brown when moist but distinctly light colored when dry. The subsoil, which extends to a depth of 56 inches, is firm clay loam. It is dark brown to brown in the upper 3 inches and dark yellowish brown below.

Gara soils have a high available moisture holding capacity and moderately slow permeability. The surface and subsurface layers are medium acid to slightly acid. The subsoil is strongly acid to very strongly acid in the most acid part, and the substratum is neutral to mildly alkaline and calcareous in places. Uneroded Gara soils are low in available nitrogen and low to very low in available phosphorus and available potassium. Where eroded, these soils are very low in available nitrogen. Steep or eroded areas have very low productivity.

Typical profile of Gara loam, 560 feet west and 300 feet south of the northeast corner of the SW¼SE¼ of section 24, T. 77 N., R. 11 W., on a slope of 20 percent that faces west:

A1—0 to 6 inches, very dark grayish-brown (10YR 3/2) loam, grayish brown (10YR 5/2) when dry, very dark grayish brown (10YR 3/2) when kneaded; moderate, fine and very fine, granular structure; friable; slightly acid; abrupt, smooth boundary.

A2—6 to 9 inches, dark grayish-brown (10YR 4/2) loam, dark grayish brown (10YR 4/2) when kneaded; few, fine, faint mottles of yellowish brown (10YR 5/4); weak, medium, platy structure that breaks to weak, fine and very fine, granular structure; friable; distinct, continuous, graying coats that are white (10YR 8/1) when dry; medium acid; clear, smooth boundary.

B1t—9 to 12 inches, light silty clay loam that has dark-brown to brown (10YR 4/3) ped exteriors and yellowish-brown (10YR 5/4) ped interiors; few, fine, faint mottles of yellowish brown (10YR 5/6); weak, fine, subangular blocky structure that breaks to weak, fine, granular structure; firm; very few, thin, discontinuous clay films; distinct, discontinuous, grainy coats that are white (10YR 8/1) when dry; few pebbles; strongly acid; clear, smooth boundary.

B21t—12 to 25 inches, medium to heavy clay loam that has dark yellowish-brown (10YR 4/4) ped exteriors and yellowish-brown (10YR 5/6) ped interiors; few, fine, faint mottles of strong brown (7.5YR 5/8); moderate, fine and very fine, subangular blocky structure; firm; common, thin, discontinuous clay films; few, thin, discontinuous grainy coats that are white (10YR 8/1) when dry; few, fine, soft concretions of a black oxide; few pebbles and stones; strongly acid; gradual, smooth boundary.

B22t—25 to 43 inches, medium clay loam that has dark yellowish-brown (10YR 4/4) ped exteriors and yellowish-brown (10YR 5/6) ped interiors; common, fine, faint mottles of yellowish brown (10YR 5/8), few, fine, distinct mottles of gray to light gray (5Y 6/1) and strong brown (7.5YR 5/6); weak, fine, prismatic structure that breaks to moderate, very fine, subangular blocky structure and to fine, angular, blocky structure; firm; common, thin to medium, continuous clay films; few, thick, discontinuous clay films; few dark-brown to brown (7.5YR 4/2) clay fills in old root channels; few black stains, 4 to 5 millimeters across, along ped faces; few, fine, soft concretions of a black oxide; common glacial rocks about an eighth of an inch or more in diameter; strongly acid; gradual, smooth boundary.

B3t—43 to 56 inches, medium clay loam that has dark yellowish-brown (10YR 4/4) ped exteriors and yellowish-brown (10YR 5/6) ped interiors; common, fine, distinct mottles of light brownish gray (2.5Y 6/2); weak, medium, prismatic structure; firm; very few, thin, dark-brown to brown (7.5YR 4/2) clay fills in old root channels; common black stains, 2 to 4 millimeters across, on prism faces; common, fine, soft concretions of a black oxide; common glacial rocks about an eighth of an inch in diameter and a few about a quarter to a half inch in diameter; neutral; clear, smooth boundary.

The A1 horizon ranges from very dark gray to very dark grayish brown in color and from 6 to 10 inches in thickness. The A2 horizon is generally weakly expressed and is mixed into the Ap horizon in places. In places thin horizons that are as much as 38 percent clay occur in the B horizon. The B2 horizon ranges from light to heavy clay loam. The grainy coats in the B horizon are white or light gray when dry. The substratum occurs at a depth of 40 inches or more and is yellowish-brown, firm, massive clay loam that is mottled. These soils are typically medium acid to very strongly acid in the most acid part. Carbonates are leached to a depth of 40 inches or more.

Gara soils have a thinner, normally lighter colored surface layer than Shelby soils. They have a thicker, normally darker colored surface layer than the Lindley soils and a thinner subsurface layer that is less well defined.

Gara loam, 9 to 14 percent slopes, moderately eroded (GaD2).—This soil has a very dark grayish-brown loam plow layer 6 to 8 inches thick. This layer consists of the surface and subsurface layers mixed with a small amount of subsoil. The subsoil is mainly dark-brown to yellowish-brown clay loam.

This soil occurs on side slopes, generally below moderately sloping or moderately steep Adair or Ladoga soils. It normally lies above Colo-Ely silty clay loams, 2 to 5 percent slopes, or Radford-Ely complex, 2 to 5 percent slopes, in the narrow drainageways. Some areas are above strongly sloping Gara soils.

Included with this soil in mapping, along the upper parts of slopes, are small areas where the subsoil is reddish brown or yellowish red and contains more clay than that of this Gara loam. Also included are more severely eroded areas that have a clay loam surface layer, and in a few areas the yellowish-brown subsoil is exposed.

This soil is generally in crops or pasture. Since runoff is rapid, the hazard of erosion is severe. Where this soil is terraced and tilled on the contour to reduce the erosion hazard, row crops can be grown occasionally. A better practice, however, is to keep this soil in hay or pasture and to plant row crops only when it is necessary to renovate the hay or pasture.

This soil requires additions of lime and liberal applications of fertilizer or manure for good crop growth. The organic-matter content is low, and tilth is poor in many places. Tilth can be improved by growing more meadow crops. Large additions of phosphorus are needed, especially for growing legumes. (Capability unit IVe–3; woodland suitability group 2)

Gara loam, 14 to 18 percent slopes (GaE).—In this soil, the surface layer is very dark grayish-brown loam 3 to 5 inches thick, and the subsurface is very dark grayish-brown or dark grayish-brown loam ranging in thickness from less than 2 inches to 5 inches. This soil is on side slopes below Adair or Ladoga soils and above Colo-Ely silty clay loams, 2 to 5 percent slopes, or Radford-Ely complex, 2 to 5 percent slopes, in narrow drainageways. Where it is adjacent to the valleys of major streams, this soil normally grades to the Olmitz and Ely soils, or to soils of the first bottoms.

Included with this soil in mapping are small areas of Colo-Ely silty clay loams, 2 to 5 percent slopes, and of Radford-Ely complex, 2 to 5 percent slopes, in narrow drainageways. Along the upper parts of slopes, areas are included that have a yellowish-red or reddish-brown clay loam or clay subsoil.

This soil is better suited to trees or pasture than to row crops. It generally is in trees, but a few areas have been cleared and are in permanent pasture. This soil is low in organic-matter content and requires additions of lime for good growth of pasture plants. Because slopes are strong and the subsoil has moderately slow permeability, runoff is rapid and the hazard of erosion is very severe. (Capability unit VIe–1; woodland suitability group 2)

Gara loam, 14 to 18 percent slopes, moderately eroded (GaE2).—This soil is similar to Gara loam, 9 to 14 percent slopes, moderately eroded. It occurs on side slopes, normally below Adair or Ladoga soils and above Colo-Ely silty clay loams, 2 to 5 percent slopes, or Radford-Ely complex, 2 to 5 percent slopes, in narrow drainageways. Where it is adjacent to the valleys of major streams, this soil normally grades to Olmitz or Ely soils or to soils of the first bottoms.

Included with this soil in mapping are small areas of Colo-Ely silty clay loams, 2 to 5 percent slopes, and of Radford-Ely complex, 2 to 5 percent slopes, in narrow drainageways. Along the upper parts of slopes, soils are included that have a reddish-brown or yellowish-red heavy clay loam or clay subsoil and a few areas where erosion has exposed the yellowish-brown subsoil.

This soil is used for pasture and row crops. It is better suited to pasture and meadow than to row crops. Because the slopes are steep and the clay loam subsoil has moderately slow permeability, runoff is rapid and the hazard of erosion is very severe. Because the organic-matter content is low and tilth generally is poor, applications of barnyard manure and more meadow crops are needed. Additions of lime also are required for good growth of pasture plants. (Capability unit VIe–1; woodland suitability group 2)

Gara loam, 18 to 25 percent slopes, moderately eroded (GaF2).—This soil has a friable, very dark grayish-brown to dark grayish-brown surface layer 4 to 6 inches thick and a dark yellowish-brown to yellowish-brown clay loam subsoil that has moderately slow permeability. It generally occurs in strongly dissected areas below the strongly sloping Adair or Ladoga soils. It is above soils on the first bottoms and on foot slopes and above areas of Colo-Ely silty clay loams, 2 to 5 percent slopes, and Radford-Ely complex, 2 to 5 percent slopes.

Included with this soil in mapping are areas that have a slightly darker surface layer than Gara loam and areas where erosion has exposed the yellowish-brown subsoil. Also included, in the narrow drainageways, are areas of Colo-Ely silty clay loams, 2 to 5 percent slopes, and of Radford-Ely complex, 2 to 5 percent slopes.

This soil is in trees and permanent pasture. Wooded areas should be managed as woodland. Careful management to control erosion is needed on pasture. This soil is suitable for wildlife areas. It is not suited to row crops, mainly because runoff is rapid and erosion is a very severe hazard. (Capability unit VIIe–1: woodland suitability group 3)

Gara soils, 14 to 18 percent slopes, severely eroded (GrE3).—These soils have a dark-brown to yellowish-brown clay loam plow layer 5 to 7 inches thick. This layer consists mostly of subsoil mixed with a small amount of the original surface layer. It is sticky when wet. These soils are in narrow bands on side slopes below the strongly sloping Adair or Ladoga soils. They are above the more strongly sloping Gara soils, Colo-Ely silty clay loams, 2 to 5 percent slopes, or Radford-Ely complex, 2 to 5 percent slopes. Other areas are above soils of the first bottoms and foot slopes. Areas are smaller than 10 acres in most places.

Included with these soils in mapping are areas that have a yellowish-red or reddish-brown subsoil that normally is clay rather than clay loam. Some areas are included that are cut by small gullies.

These soils generally are in crops, but a few areas are in permanent pasture. They are better suited to pasture than to row crops, but yields of both are low.

Because these soils are in poor tilth, it is difficult to prepare good seedbeds. New seedings and existing pastures respond well to additions of phosphate. On newly seeded pastures, grazing should be avoided until the plants are well established. On established pastures, good grazing management is needed because runoff is high and the hazard of erosion is very severe. Additions of lime are beneficial. (Capability unit VIIe–1; woodland suitability group 2)

Givin Series

The Givin series consists of somewhat poorly drained soils that developed from loess under mixed native prairie grasses and trees. These soils are on upland ridges and high stream benches where slopes are convex and range from 1 to 3 percent.

In a typical profile the surface layer, about 8 inches

thick, is very dark grayish-brown silt loam. The subsurface layer, about 4 inches thick, is dark grayish-brown silt loam that is distinctly light colored when dry. The subsoil is friable to firm silty clay loam that extends to a depth of about 50 inches. It is very dark grayish brown, dark grayish brown, grayish brown, and yellowish brown and has mottles of yellowish brown and strong brown below a depth of about 16 inches. At a depth of about 42 inches, the subsoil is a grayish-brown, friable to firm light silty clay loam that is distinctly mottled with yellowish brown and strong brown.

Givin soils have a high available moisture holding capacity and moderately slow permeability. The surface and subsurface layers are medium to slightly acid, the subsoil is medium acid to strongly acid, and the substratum is medium acid to slightly acid. Givin soils are low in available nitrogen and available phosphorus, and very low in available potassium.

Typical profile of Givin silt loam, 530 feet west and 300 feet north of the NE¼SW¼ section 24, T. 76 N., R. 11 W., on a 1 percent slope:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak, coarse, subangular blocky structure that breaks to weak, fine, granular structure; friable; medium acid; abrupt, smooth boundary.

A2—8 to 12 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) when dry; weak, thick, platy structure that breaks to moderate, thin platy structure; friable; discontinuous very dark grayish-brown ped coats; discontinuous grainy ped coatings that are light gray (10YR 7/1) when dry; medium acid; clear, smooth boundary.

B1—12 to 16 inches, light silty clay loam that has very dark grayish-brown (10YR 3/2) ped exteriors and dark grayish-brown (10YR 4/2) ped interiors; moderate, fine, subangular blocky structure; friable; nearly continuous grainy ped coats that are light brownish gray (10YR 6/2) when dry; strongly acid; gradual, smooth boundary.

B21t—16 to 23 inches, medium silty clay loam that has dark grayish-brown (10YR 4/2) ped exteriors and brown (10YR 4/3) ped interiors; few, fine, faint mottles of yellowish brown (10YR 5/4); moderate, fine, subangular blocky and fine, angular blocky structure; firm; few, fine concretions of dark reddish-brown and dark-brown oxides; few discontinuous clay films; nearly continuous grainy ped coats that are light gray (10YR 7/1) when dry; strongly acid; gradual, smooth boundary.

B22t—23 to 34 inches, heavy silty clay loam that has grayish-brown (10YR 5/2) ped exteriors and dark grayish-brown (10YR 4/2) ped interiors; common, fine, distinct mottles of yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6); weak, medium, prismatic structure that breaks to moderate, medium, subangular and angular blocky structure; firm; few concretions of dark-brown and dark reddish-brown oxides; few, thick, discontinuous clay films; few patchy grainy ped coats that are light brownish gray (10YR 6/2) when dry; strongly acid; gradual, smooth boundary.

B23t—34 to 42 inches, mottled dark grayish-brown (10YR 4/2), grayish-brown (2.5Y 5/2), and yellowish-brown (10YR 5/6) medium silty clay loam; weak, medium, prismatic structure that breaks to weak, coarse, angular blocky structure; firm; thin, nearly continuous clay films; common, fine concretions of dark reddish-brown and dark-brown oxides; medium acid; gradual, smooth boundary.

B3t—42 to 50 inches, grayish-brown (2.5Y 5/2) light silty clay loam that has many, distinct, yellowish-brown (10YR 5/6) and few strong-brown (7.5YR 5/6) mottles; weak, medium to coarse, prismatic structure; firm; discontinuous clay films on prism faces and clay fills in root channels; few clay balls about a quarter inch in diameter; common dark reddish-brown and brown concretions of an oxide; medium acid.

The A1 horizon ranges from very dark gray to very dark grayish brown in color and from 6 to 10 inches in thickness. The A2 horizon ranges from very dark gray to dark grayish brown in color and from 4 to 8 inches in thickness. The mottled B horizon ranges from dark grayish brown to olive gray and from medium silty clay loam to very light silty clay. Clay films on the B horizon are medium and discontinuous to thin and continuous. The solum is strongly acid in the most acid part.

Givin soils have a light-colored subsurface layer that does not occur in the Mahaska soils. The dark-colored A surface layer is thicker in the Givin soil than that in the Keomah soils. Givin soils have browner colors in the upper part of the subsoil than Rubio soils and a less abrupt change in content of clay between the subsurface layer and the subsoil.

Givin silt loam, 1 to 3 percent slopes (GsA).—This soil has a very dark grayish-brown surface layer 6 to 10 inches thick and a dark grayish-brown silt loam subsurface layer 4 to 8 inches thick. The subsoil is dark grayish-brown silty clay loam mottled with yellowish brown. This soil is medium in organic-matter content, and there is little or no hazard of erosion.

This soil occurs adjacent to Rubio soils on the nearly level ridgetops and narrow divides of the uplands. It is usually above the gently sloping Ladoga soils, but some areas are above gently sloping Clinton soils. Areas of this soil within individual fields are often 20 acres or more in size. Included with this soil in mapping are small areas of level to slightly depressional, poorly drained soils.

This soil is used intensively for row crops. It is well suited to corn, soybeans, small grains, forage grasses, and legumes.

Where this soil is used for row crops, it must be managed carefully to maintain good tilth. It is moderately high to high in fertility. The soil is acid unless recently limed. The larger areas of this soil can be improved by the installation of tile drains. (Capability unit I–1; woodland suitability group 4)

Givin silt loam, benches, 1 to 3 percent slopes (GtA).—This soil has a very dark grayish-brown surface layer 6 to 10 inches thick and a very dark brown subsurface layer 4 to 8 inches thick. The subsoil is dark grayish brown mottled with yellowish brown and has moderately slow permeability. This soil is medium in organic-matter content, and there is little or no hazard of erosion.

This soil occurs on loess-covered benches along the major streams, mostly the North and South Skunk Rivers. These benches are underlain by alluvium at a depth of 10 to 15 feet. This soil occurs along or below the level to slightly depressional Rubio soils and above the gently sloping Ladoga soils. Areas of this soil range from about 5 acres to 20 acres or more, and areas within individual fields are sometimes 12 to 15 acres. Small areas of level to slightly depressional, poorly drained soils are included with this soil in mapping.

This soil is used intensively for row crops. It is moderately fertile and is well suited to corn, soybeans, small grains, forage grasses, and legumes.

Crops respond well if fertilizer is added. Also beneficial are additions of lime. Larger areas of this soil are

improved by the installation of tile drains. (Capability unit I–1; woodland suitability group 4)

Gosport Series

The Gosport series consists of moderately well drained soils that were derived from bedrock of olive-brown and yellowish-brown clayey shale. These soils are on the lower parts of convex side slopes adjacent to the valley of the Skunk River. Slopes range from 14 to 25 percent. The native vegetation was trees.

The typical surface layer, where uneroded or not cultivated, is very dark brown silt loam about 3 inches thick. The 2-inch subsurface layer is brown silty clay loam that is distinctly light colored when dry. The subsoil, which extends to a depth of 22 inches, is brown to yellowish-brown heavy silty clay loam in the upper part, light olive-brown, very firm, mottled silty clay in the middle, and dark-gray and dark grayish-brown mottled silty clay in the lower part. Mottles occur in the subsoil at a depth of 10 inches. The underlying material is gray and dark yellowish-brown silty clay shale.

Gosport soils have very slow permeability and a moderately high available moisture holding capacity. The surface and subsurface layers are neutral to medium acid. The subsoil and substratum are very strongly acid to medium acid. These soils are very low in available nitrogen, available phosphorus, and available potassium.

Typical profile of Gosport silt loam, 150 feet south and 150 feet west of the northeast corner of the NW¼NW¼ of section 30, T. 75 N., R. 12W., on a convex side slope of 20 percent that faces east:

A1—0 to 3 inches, very dark brown (10YR 2/2) silt loam; weak, fine, subangular blocky and granular structure; friable; small pebbles; slightly acid; abrupt, smooth boundary.

A2—3 to 5 inches, brown (10YR 5/3) light silty clay loam; weak, thin, platy structure; friable; few, fine, soft concretions of a black oxide; medium acid; abrupt, smooth boundary.

IIB21—5 to 10 inches, brown (10YR 5/3) to yellowish-brown (10YR 5/4) medium to heavy silty clay loam; moderate, fine, subangular blocky structure; firm; discontinuous light brownish-gray silt coats; few, fine, soft concretions of a black oxide; few laminar shale fragments; medium acid; clear, smooth boundary.

IIB22t—10 to 15 inches, light olive-brown (2.5Y 5/3) light silty clay; few, fine, distinct mottles of yellowish brown (10YR 5/4); few, thin, discontinuous clay films; moderate, fine, subangular blocky structure; very firm; common, fine, laminar shale fragments; some lignite fragments; very strongly acid; clear, smooth boundary.

IIB3—15 to 22 inches, dark-gray (5Y 4/1) and dark grayish-brown (2.5Y 4/2) silty clay; few, fine, distinct mottles of strong brown (7.5YR 5/8); weak, fine and medium, subangular blocky structure; very firm; some laminar lignite fragments; very strongly acid; clear, smooth boundary.

IIC1—22 to 33 inches, gray (5Y 5/1) and dark yellowish-brown (10YR 4/4), laminated silty clay shale; very strongly acid; gradual, smooth boundary.

IIC2—33 to 47 inches, gray (5Y 5/1) and dark yellowish-brown (10YR 4/4), laminated silty clay shale; medium acid.

The A1 horizon ranges from very dark brown to very dark grayish brown in color and from 2 to 5 inches in thickness. The A2 horizon ranges from dark grayish brown to brown in color and from 2 to 5 inches in thickness. Where cultivated, the A1 and A2 horizons have been mixed together and the plow layer is dark grayish brown. The B horizon ranges from dark gray to yellowish brown or strong brown in color and from heavy silty clay loam to silty clay or clay in texture. The original laminar rock structure is visible in the B3 horizon. Depth to laminated shale bedrock ranges from 20 to 36 inches. The solum is very strongly acid in the most acid part.

Gosport soils have a more acid subsoil than the Dunbarton soils. Gosport soils are underlain by silty clay shale rather than by limestone flags as are the Dunbarton soils, by limestone as are the Sogn soils, or by sandstone as are the Boone soils.

Gosport silt loam, 14 to 25 percent slopes, moderately eroded (GuE2).—This soil has a very dark brown to very dark grayish-brown surface layer 2 to 6 inches thick and a very dark brown to brown subsurface layer 2 to 5 inches thick. The subsoil developed in shale and is very slowly permeable. This soil is low in organic-matter content. The erosion hazard is very severe.

This moderately well drained soil is in the strongly dissected areas adjacent to major stream valleys. It generally occurs on lower slopes below Lindley, Keswick, or Clinton soils. It normally occurs above the soils of the bottoms or foot slopes and the narrow drainageways, the Radford-Ely complex, 2 to 5 percent slopes, or Nodaway-Martinsburg silt loams, 2 to 5 percent slopes.

Included with this soil in mapping are areas that are only strongly sloping and some areas where slopes are very steep. In other included areas a thin layer of loess lies over the shale. Also included, generally on strong to moderately steep slopes, are areas of soils that have a surface layer formed in glacial till.

This soil generally is in permanent pastures of low quality or in trees. Although they are not suited to row crops, there are a few isolated strongly sloping areas in cultivated fields. Pasture plants and trees grow better than row crops on this soil, but growth is poor because fertility is low and tilth is generally poor. Considerable care should be taken to improve stands when pastures are renovated. Since water infiltration is slow and runoff is rapid, the erosion hazard is very severe. In this normally acid soil, additions of lime are needed to insure legume stands. (Capability unit VIIe–1; woodland suitability group 8)

Humeston Series

The Humeston series consists of very poorly drained soils that developed in silty alluvium that contains little sand. The native vegetation was prairie grasses, trees, and sedges tolerant of excess wetness. These soils are in slight depressions on low stream benches and first bottoms along the English and Skunk Rivers. Water collects or drains into these depressions.

In a typical profile the surface layer is black and very dark gray silt loam about 10 inches thick. The subsurface layer, about 5 inches thick, is very dark gray, dark-gray, and gray, friable silt loam. The subsoil extends to a depth of 57 inches. It is very dark gray silty clay loam in the upper part and black, very dark gray, and dark-gray silty clay below. Mottles of olive brown are below a depth of 50 inches.

Humeston soils have a high available moisture holding capacity. They are slowly to very slowly permeable. The surface layer ranges from neutral to medium acid, and the subsurface layer and subsoil are slightly acid to

mildly alkaline, but are not calcareous. These soils are low in available nitrogen, medium in available phosphorus, and very low in available potassium.

Typical profile of Humeston silt loam, 1,140 feet south and 280 feet west of the northeast corner of the NW¼-NE¼ section 3, T. 74 N., R. 12 W., on a nearly level low stream terrace:

Ap—0 to 6 inches, black (10YR 2/1) heavy silt loam, gray (10YR 5/1) when dry; weak, fine, subangular blocky and granular structure; friable; neutral; abrupt, smooth boundary.

A1—6 to 10 inches, very dark gray (10YR 3/1) to black (10YR 2/1) silt loam, gray (10YR 5/1) when dry, very dark gray (10YR 3/1) when kneaded; moderate, very fine and fine, subangular and angular blocky structure; friable; neutral; clear, smooth boundary.

A2—10 to 15 inches, very dark gray (10YR 3/1), dark-gray (10YR 4/1), and gray (10YR 5/1) silt loam, light gray (N 7/0), when dry, dark gray (10YR 4/1) when kneaded; moderate, thin, platy structure; friable; few, fine, soft concretions of a dark-brown oxide; slightly acid; clear, smooth boundary.

B1—15 to 18 inches, very dark gray (10YR 3/1) medium silty clay loam, gray (10YR 6/1) when dry; moderate, fine, angular blocky structure; friable to firm; grainy coats on some peds; few, fine, soft concretions of a dark-brown oxide; slightly acid; clear, smooth boundary.

B21t—18 to 26 inches, black (10YR 2/1) silty clay; strong, very fine, subangular and angular blocky structure; firm; thin continuous clay films; slightly acid; clear, smooth boundary.

B22t—26 to 34 inches, very dark gray (10YR 3/1) silty clay; strong, very fine, subangular and angular blocky structure; very firm; continuous clay films; few, fine, soft concretions of a dark-brown oxide; neutral; clear, smooth boundary.

B23tg—34 to 50 inches, very dark gray (10YR 3/1) and dark-gray (10YR 4/1) silty clay; moderate, fine, subangular blocky structure; firm; few, thin, black (10YR 2/1) clay films on ped faces; few, fine, soft concretions of strong-brown and black oxides; mildly alkaline; gradual, smooth boundary.

B3tg—50 to 57 inches, dark-gray (10YR 4/1) silty clay; common, fine, distinct mottles of olive brown (2.5Y 4/4); weak, medium, prismatic structure that breaks to moderate, fine to medium, subangular blocky structure; firm; very few, thin, discontinuous clay films; few, fine, soft concretions of a yellowish-brown oxide; neutral.

The A1 horizon ranges from black to very dark gray in color and from 10 to 14 inches in thickness. The A1 horizon ranges from very dark gray to gray in color and from 6 to 12 inches in thickness. The B2 horizon is black in the upper part but grades to dark gray as depth increases. In the B2 horizon, the content of clay ranges from about 38 to 48 percent. Yellowish-brown and olive-brown mottles occur below a depth of about 40 inches in some places. The solum is slightly acid in the most acid part.

Humeston soils have a thinner subsurface layer than Vesser soils and typically a subsoil that is more clayey nearer the surface. Humeston soils have a thicker surface layer and darker colored subsoil than Tuskeego soils and, in many places, are less acid throughout the subsoil. Humeston soils have more clay in the lower part of the subsoil than Sperry soils and a less abrupt increase of clay between the subsurface layer and the subsoil. They have a gray subsurface layer, which is lacking in the Chequest soils, and a surface layer that is thinner than in the Chequest soils.

Humeston silt loam (Hu).—This soil has a black to very dark gray surface layer 8 to 10 inches thick and a leached subsurface layer that is very dark to dark grayish brown and 6 to 12 inches thick. The subsurface layer is abruptly underlain by a thick clay subsoil that is slowly to very slowly permeable. This soil occurs on low stream terraces along the major stream valleys in the county. It is closely associated with the Vesser, Tuskeego, Koszta, Chequest, and Wabash soils.

Humeston silt loam is used intensively for row crops, but a few areas are in pasture. This soil is wet; runoff from the uplands ponds in the depressional areas, and some other areas are flooded. Where fieldwork is delayed in spring because of wetness, soybeans are often substituted for corn. In meadows legumes often are winterkilled.

Because the subsoil is slowly permeable to very slowly permeable, tile lines do not drain this soil well. Open ditches, however, can be used to remove excess surface water. But even where drainage is improved, this soil is often hard to work. Additions of lime may be needed in some areas. (Capability unit IIIw-2; woodland suitability group 10)

Judson Series

The Judson series consists of moderately well drained to well drained soils that developed from local silty alluvium. This alluvium washed from adjacent loess-derived soils on uplands. The native vegetation was prairie grasses. These soils are on low, nearly straight or slightly concave foot slopes and alluvial fans. Slopes range from 3 to 7 percent.

In a typical profile the surface layer is black or very dark brown and very dark grayish-brown silty clay loam 30 inches thick. The subsoil, which extends to a depth of 60 inches, is brown. These layers are friable light to medium silty clay loam. A few grayish-brown mottles occur below a depth of about 40 inches.

Judson soils have a high available water holding capacity and are moderately permeable. The surface layer is neutral to slightly acid, the subsoil is medium acid to slightly acid, and the substratum is slightly acid to neutral. Most Judson soils in Keokuk County are medium in available nitrogen and low in available phosphorus and available potassium.

Typical profile of a Judson silty clay loam, 300 feet south and 600 feet west of the northeast corner of the SW¼NE¼ section 11, T. 77 N., R. 10 W.; concave foot slope of 6 percent facing southwest:

Ap—0 to 6 inches, black (10YR 2/1) to very dark brown (10YR 2/2) light silty clay loam, very dark brown (10YR 2/2) when kneaded; cloddy, breaking to weak, fine, granular structure; friable; neutral; abrupt, smooth boundary.

A11—6 to 15 inches, black (10YR 2/1) and very dark brown (10YR 2/2) light silty clay loam, very dark brown (10YR 2/2) when kneaded; moderate, fine, granular structure; friable; neutral; clear, smooth boundary.

A12—15 to 23 inches, light silty clay loam that has very dark brown (10YR 2/2) ped exteriors and very dark grayish-brown (10YR 3/2) ped interiors; very dark grayish brown (10YR 3/2) when kneaded; moderate, fine, granular and moderate, very fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

A3—23 to 30 inches, medium silty clay loam that has very dark grayish-brown (10YR 3/2) ped exteriors and dark yellowish-brown (10YR 4/4) ped interiors; moderate, very fine, subangular blocky structure; friable; few, fine, soft concretions of a black oxide; medium acid; clear, smooth boundary.

B21t—30 to 40 inches, medium silty clay loam that has brown (10YR 4/3) ped exteriors and yellowish-brown (10YR 5/4) ped interiors; moderate, fine, prismatic structure that breaks to moderate, very fine, subangular blocky structure; friable; very few, thin, discontinuous clay films; few, fine, soft concretions of a black oxide; discontinuous, faint, grainy ped coats, gray when dry; medium acid; clear, smooth boundary.

B22t—40 to 49 inches, light to medium silty clay loam that has brown (10YR 5/3) ped exteriors and yellowish-brown (10YR 5/4) ped interiors; few, fine, distinct mottles of grayish brown (2.5Y 5/2); moderate, fine, prismatic structure that breaks to moderate, fine, subangular blocky structure; friable; very few, thin, discontinuous clay films; few, fine, soft concretions of black and strong-brown oxides; discontinuous, faint, grainy ped coats, gray when dry; medium acid; clear, smooth boundary.

B3t—49 to 60 inches, light silty clay loam that has brown (10YR 5/3) ped exteriors and yellowish-brown (10YR 5/4) ped interiors; common, fine, distinct mottles of grayish brown (2.5Y 5/2); weak, medium, prismatic structure that breaks to weak, medium, subangular blocky structure; friable; very few, thin, clay films in pores; common, fine, soft concretions of black and strong-brown oxides; nearly continuous, faint, grainy ped coats, gray when dry; slightly acid.

The A1 horizon is dominantly very dark brown, but it ranges from black or very dark brown to very dark gray. It ranges from heavy silt loam to light silty clay loam. It typically has a content of clay less than 35 percent, and the clay content in the B horizon is not much higher than that in the A. The B horizon ranges from very dark grayish brown to brown. In some places clay films do not occur in the B horizon. The solum is slightly acid to medium acid in the most acid part. The substratum is similar to the B horizon in color and content of clay.

Judson soils have a browner upper subsoil than the Ely soils and a thicker, darker colored surface layer than the Martinsburg soils. The surface layer of Judson soils is thicker than that in the Watkins soils, and the subsoil is less distinct and does not have so much more clay than the surface layer. Judson soils lack the grayish or brownish subsurface layer of the Martinsburg soils.

Judson silty clay loam, 3 to 7 percent slopes (JcC).—This soil has a black or very dark brown light silty clay loam surface layer 15 to 30 inches thick. It is high in organic-matter content, and the hazard of erosion is slight.

This soil occurs on foot slopes or fans parallel to the base of strongly sloping loess-covered uplands. It generally is below the Otley or Ladoga soils. In the few areas where this soil is below Adair soils, it has a thin covering of loess. It is commonly above the Colo soils, and in a few of the steeper areas, it is above the Ely soils. Small drainageways that can be crossed with machinery occur in some places.

Included with this soil in mapping are a few areas that have a silty and lighter colored surface layer.

Nearly all of this soil is cultivated. It is fertile, well suited to crops, and can be cropped intensively without excess soil losses where it is tilled on the contour.

This Judson soil is generally farmed with the soils on bottoms rather than with the more sloping soils on uplands. Diversion terraces are used to carry away excess runoff from the uplands. These terraces should be built at the junction of this Judson soil and soils at the base of the upland slopes. This soil is acid in places, and benefits from additions of lime. (Capability unit IIe-2; woodland suitability group 1)

Keomah Series

The Keomah series consists of somewhat poorly drained soils that developed from loess. The native vegetation was trees. These soils have slopes of 1 to 3 percent and occur on moderately wide upland ridgetops and high stream benches. They are closely associated with the Clinton soils.

In a typical profile the surface layer is very dark grayish-brown silt loam about 7 inches thick. The subsurface layer is dark grayish-brown and grayish-brown, friable silt loam that has a few yellowish-brown mottles. The subsoil extends to a depth of about 61 inches. It is a silty clay loam that is brown and dark grayish brown mottled with yellowish brown in the upper part and grayish brown mottled with strong brown and reddish yellow at a depth below 41 inches.

Keomah soils are moderately slowly permeable and have a high available moisture holding capacity. The surface layer is neutral to slightly acid, the subsurface typically is medium acid, the subsoil is medium acid to strongly acid, and the substratum is generally slightly acid. These soils are low to very low in available nitrogen, medium in available phosphorus, and very low in available potassium.

Typical profile of a Keomah silt loam, 617 feet east and 905 feet north of the southwest corner of the NE¼ section 17, T. 74 N., R. 12 W., on a ridgetop that has a convex slope of 1 percent that faces south:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) silt loam, dark grayish brown (10YR 4/2) when kneaded; weak, fine, granular structure; friable; few, fine, manganese concretions; neutral; clear, smooth boundary.

A12—7 to 11 inches, dark grayish-brown (10YR 4/2) silt loam, dark grayish brown (10YR 4/2) when kneaded; few, fine, faint mottles of yellowish brown (10YR 5/4); weak, medium, platy structure that breaks to moderate, fine, granular structure; friable; nearly continuous grainy coating, light gray (10YR 7/1) when dry; few, fine, iron and manganese concretions; medium acid; clear, smooth boundary.

A22—11 to 17 inches, grayish-brown (2.5Y 5/2) silt loam; common, fine, distinct mottles of yellowish brown (10YR 5/4); weak, thin, platy structure that breaks to weak, fine, granular structure; friable; nearly continuous grainy coats, light gray (10YR 7/1) when dry; few, fine, iron and manganese concretions; medium acid; clear, smooth boundary.

B1—17 to 21 inches, light silty clay loam that has mottled dark grayish-brown (2.5Y 4/2) ped exteriors, brown (10YR 4/3) and dark grayish-brown (10YR 5/2) ped interiors; common, fine, distinct mottles of yellowish brown (10YR 5/4); moderate, fine and very fine, subangular blocky structure; friable to firm; nearly continuous grainy coats, light brownish gray (10YR 6/2) when dry; common, fine, dark yellowish-brown concretions of a soft oxide; strongly acid; clear, smooth boundary.

B21t—21 to 34 inches, heavy silty clay loam that has brown (10YR 4/3) ped exteriors and dark yellowish-brown (10YR 4/4) and grayish-brown (10YR 5/2) ped interiors; common, fine, faint mottles of yellowish brown (10YR 5/6); weak, fine, prismatic structure that breaks to moderate, fine and very fine, subangular blocky structure; firm; thin, nearly continuous clay films; few, fine concretions of iron and manganese; strongly acid; clear, smooth boundary.

B22t—34 to 41 inches, medium silty clay loam that has dark-brown to brown (10YR 4/3) ped exteriors and dark yellowish-brown (10YR 4/4) ped interiors; common, fine, distinct mottles of yellowish brown (10YR 5/6)

and common, fine, prominent mottles of strong brown (7.5YR 5/8); weak, medium, prismatic structure that breaks to weak, fine and medium, subangular blocky structure; firm; thin, nearly continuous clay films; common iron and manganese concretions; strongly acid; gradual, smooth boundary.

B3t—41 to 61 inches, grayish-brown (2.5Y 5/2) medium silty clay loam; few, fine, prominent mottles of strong brown (7.5YR 5/8); weak, medium, subangular blocky structure to massive (structureless); firm; thin, discontinuous clay films on ped faces; common, fine concretions of iron and manganese; medium acid; gradual, smooth boundary.

The A1 horizon ranges from very dark gray to very dark grayish brown to dark grayish brown in color. It is 4 to 6 inches thick. The A2 horizon ranges from dark grayish brown to grayish brown and brown in color and from 6 to 12 inches in thickness. Matrix colors of the B horizon are dark grayish brown, grayish brown, or brown and mottles are strong brown and yellowish brown. The B horizon has a content of clay of 35 to 42 percent. These soils are leached of carbonates to a depth of at least 60 inches and are strongly acid in the most acid part.

Keomah soils have a grayer, more mottled subsoil than the Clinton soils. The surface layer is lighter colored than that of the Givin soils, and the subsurface layer is more distinct.

Keomah silt loam, 1 to 3 percent slopes (KeA).—This soil has a very dark grayish-brown to dark grayish-brown surface layer 4 to 8 inches thick. The subsurface layer, 6 to 12 inches thick, is dark grayish brown to grayish brown and is lighter colored when dry. In some places the surface has been mixed with some of the subsurface layer to form a lighter colored plow layer. The subsoil is dark grayish-brown to grayish-brown silty clay loam that is moderately slowly permeable.

This soil is on uplands, normally surrounded by moderately well drained, nearly level Clinton soils.

Included with this soil in mapping are many areas of slightly depressional soils that are more poorly drained than Keomah soils and have a darker colored surface layer and a more clearly defined subsurface layer.

This Keomah soil is used intensively for row crops. It is suited to corn, soybeans, small grains, forage grasses, and legumes.

Although crops grow moderately well on this soil, it requires drainage improvement in a few places. Tile lines function satisfactorily, but in places drainage through them tends to be slow. This soil is low in organic-matter content, but tilth is generally good. Tilth generally can be improved by additions of manure and by growing a meadow crop for an additional year. Corn and small grains respond especially well to additions of nitrogen, but the nitrogen should be in a balanced mixture containing phosphorus and potassium. Additions of lime are beneficial. (Capability unit I-1; woodland suitability group 4)

Keswick Series

The Keswick series consists of moderately well drained soils that developed from clayey, reddish, weathered glacial till under a native vegetation of trees. These soils occupy narrow ridgetops and the shoulders of convex side slopes. They are below the loess-derived Clinton soils and above the till-derived Lindley soils. Slopes range from 9 to 18 percent. Some of the steeper soils are closely intermingled with the Lindley soils.

In a typical profile the surface layer is very dark gray and very dark brown loam to silt loam about 3 inches thick. The subsurface layer, about 6 inches thick, is grayish-brown and brown loam to silt loam mottled with yellowish red. A few fragments of stone and small pebbles are present in the lower part of the subsurface layer. The subsoil extends to a depth of 52 inches. To a depth of 28 inches, it is firm and very firm clay that is brownish, reddish, and yellowish and is mottled. Below 28 inches it is brownish and yellowish clay loam mottled with red and strong brown. The underlying material is yellowish-brown sandy clay loam mottled with yellowish red and strong brown. Glacial stones and pebbles occur in the subsoil and underlying material.

Keswick soils have a high available moisture holding capacity and are very slowly permeable. The surface and subsurface layers are medium acid to slightly acid, the subsoil is strongly acid to slightly acid, and the substratum is slightly acid to mildly alkaline. Keswick soils are very low in available nitrogen, phosphorous, and potassium.

Typical profile of Keswick loam, 320 feet east and 475 feet south of the northwest corner of the NE¼NW¼ section 17, T. 76 N., R. 11 W., on a convex side slope of 11 percent that faces north:

Ap—0 to 3 inches, very dark gray (10YR 3/1) and very dark brown (10YR 2/2) loam to silt loam, very dark grayish brown (10YR 3/2) when kneaded; few, fine, faint mottles of dark brown; weak, fine and medium, subangular blocky breaking to weak, fine, granular structure; friable; few, fine, reddish concretions of iron and manganese; few small pebbles; medium acid; clear, smooth boundary.

A2—3 to 9 inches, grayish-brown (10YR 5/2) and brown (10YR 4/3) loam to silt loam; few, fine, prominent mottles of yellowish red (5YR 5/6); moderate, fine to medium, platy structure that breaks to moderate, very fine, granular structure; friable; fillings of very dark gray (10YR 3/1) in some root channels; few, fine concretions of iron and manganese; few small pebbles; slightly acid; clear, smooth boundary.

IIB1t—9 to 19 inches, mottled grayish-brown (2.5Y 5/2) and brown (7.5YR 4/4) light clay; common, fine, prominent mottles of dark red (10R 3/6) and dark gray (10YR 4/1); moderate, very fine, subangular blocky structure; firm; common, thin grainy coats on peds in upper part; few, thin, discontinuous clay films on ped faces; strongly acid; clear, smooth boundary.

IIB21t—19 to 28 inches, clay that has dark reddish-brown (5YR 3/4) exteriors and yellowish-red (5YR 4/6) interiors; common, fine, distinct mottles of grayish brown (2.5Y 5/2) and few, fine, distinct mottles of red (10R 5/8); weak, fine, prismatic structure that breaks to strong, fine and very fine, angular blocky structure; very firm; thick, continuous clay films; few, fine concretions of a black oxide; strongly acid; clear, smooth boundary.

IIB22t—28 to 39 inches, heavy clay loam that has brown (7.5YR 4/4) ped exteriors and brownish-yellow (10YR 6/6) ped interiors; common, fine, distinct mottles of red (2.5YR 4/6) and few, fine, faint mottles of strong brown (7.5YR 5/6); weak, medium, prismatic structure that breaks to moderate, fine and medium, subangular blocky structure; very firm; common, thin to medium, discontinuous, nearly continuous clay films on ped faces; few pebbles; few, fine, black concretions of iron and manganese; medium acid; clear, smooth boundary.

IIB3t—39 to 52 inches, medium clay loam that has brown (7.5YR 4/4) ped exteriors and yellowish-brown (10YR 5/4) ped interiors; few, fine, prominent mottles of dark red (2.5YR 3/6) and strong brown (7.5YR 5/8); weak, fine, prismatic structure; firm;

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common, thin, nearly continuous clay films and few, thick, discontinuous clay films; common, fine, black stains on ped faces; few pebbles; common, fine concretions of iron and manganese; slightly acid; gradual, smooth boundary.

IIC—52 to 64 inches, yellowish-brown (10YR 5/6) medium sandy clay loam; common, fine, distinct mottles of yellowish red (5YR 5/6) and few, fine, distinct mottles of strong brown (7.5YR 5/8); massive with some vertical cleavage; firm; few clay films in pores; few pebbles and stones; few black stains in upper part of horizon; few fine concretions of iron and manganese; neutral; few lime concretions as much as an inch in diameter below a depth of 58 to 64 inches.

Unless Keswick soils are severely eroded, the A1 or Ap horizon ranges from gritty silt loam to loam in texture and from very dark brown to very dark gray in color. The Ap ranges from dark grayish brown to browner or redder colors in severely eroded areas. In many places the A2 horizon is mixed into the Ap horizon. The B horizon ranges from strong brown to yellowish brown to yellowish red and is mottled with redder colors. The B horizon ranges from heavy clay loam to clay, though light clay is the dominant texture. The maximum content of clay in the B horizon ranges from 38 to 50 percent. A stone line generally occurs in the upper part of the B horizon. Pebbles and stones increase in number as depth increases. The solum is strongly acid to very strongly acid in the most acid part.

In the Keswick soils, the subsoil is redder, more mottled, firmer, and more clayey than that in the Lindley soils. Keswick soils have a lighter-colored surface layer than Adair soils and, unlike them, a distinct grayish subsurface layer.

Keswick loam, 9 to 14 percent slopes (KsD).—This soil has a very dark grayish-brown to dark grayish-brown loam surface layer 3 to 6 inches thick. The subsurface layer is dark-brown to grayish-brown loam 3 to 6 inches thick. The subsoil is reddish-brown to yellowish-brown clay to clay loam that is very slowly permeable.

This soil occurs in bands or strips in a contour pattern immediately below the loess-till contact line in the strongly dissected areas of the county. It is generally below the moderately sloping or strongly sloping Clinton soils and above the moderately steep to steep Lindley soils.

Most of this soil is in trees, but a few areas are in pasture. Permanent hay or pasture is well suited, but existing stands of trees should be managed as woodland rather than cleared for hay or pasture. Row crops are not well suited because permeability is very slow, runoff is rapid, and the hazard of erosion is severe.

Since this soil is low in fertility, growth of hay and pasture normally is only fair. Large additions of lime and phosphorus are required if legumes are to be grown successfully. (Capability unit IVe–2; woodland suitability group 7)

Keswick loam, 9 to 14 percent slopes, moderately eroded (KsD2).—This soil has a dark grayish-brown to brown plow layer 5 to 7 inches thick. The plow layer consists mostly of remaining surface and subsurface layers mixed with a small amount of subsoil. The subsoil is reddish-brown to yellowish-brown clay to sandy clay loam. It is very slowly permeable.

This soil occurs in bands or strips in a contour pattern immediately below the loess-till contact line in the strongly dissected areas of the county. It is generally below the moderately sloping or strongly sloping Clinton soils and above the moderately steep or steep Lindley soils.

Included with this soil in mapping are areas on the shoulders of slopes and at the heads of drainageways where the clay loam subsoil is exposed by plowing. Also included, near drains in side slopes, are areas that have a thicker and darker colored surface layer than Keswick loam.

This soil is better suited to permanent hay or pasture than to cultivated crops.

This soil is sometimes wet and seepy, but excess water normally can be diverted by installing interceptor tile in the loess-derived Clinton soils upslope. Diversion terraces also can be constructed in these Clinton soils to reduce the amount of runoff. This soil is not well suited to terracing because the exposed clay subsoil is infertile and difficult to manage. (Capability unit IVe-2; woodland suitability group 7)

Keswick soils, 9 to 14 percent slopes, severely eroded (KwD3).—These soils have lost most of the original surface layer through erosion, and in many places the subsoil is exposed. The present plow layer is a dark grayish brown to strong brown and 5 to 7 inches thick. It consists of subsoil material mixed with a small amount of the remaining surface and subsurface layers. Texture is clay loam in most places.

These soils occur in bands or strips in a contour pattern immediately below the loess-till contact line in strongly dissected areas of the county. They normally are below Clinton soils and above Lindley soils. In some areas gullies are active and cannot be crossed by farm machinery.

The organic-matter content of these soils is low, and soil surfaces are clayey and in poor tilth. These soils are sticky when wet and become hard and cloddy when they dry. Water infiltration is slow, and runoff is rapid.

Included with these soils in mapping are areas where erosion has removed some of the upper subsoil, and the reddish-brown or yellowish-red clay is exposed.

In most places these soils are in crops, but some are idle areas within cropped fields. Other areas are used for permanent pasture. These soils are better suited to permanent hay or pasture than to cultivated crops.

On these Keswick soils heavy applications of barnyard manure, lime, and fertilizer increase content of organic matter and help to restore fertility. (Capability unit VIe-1; woodland suitability group 7)

Keswick-Lindley complex, 14 to 18 percent slopes, severely eroded (KxE3).—This complex is similar to Keswick soils, 9 to 14 percent slopes, severely eroded, except that the soils have a slightly thinner clay subsoil. Most of the original surface soil was lost through erosion, and subsoil is exposed in many places. The present surface layer is dark grayish-brown to strong-brown clay loam to clay. It has been mixed by tillage in most places. The reddish-brown clay subsoil is exposed in some places.

These soils occur in bands or strips in a contour pattern immediately below the loess-till contact line in strongly dissected areas of the county. They are below strongly sloping Clinton soils and normally are above steep or very steep Lindley soils. Other areas are above Nodaway-Martinsburg silt loams, 2 to 5 percent slopes, or Radford-Ely complex, 2 to 5 percent slopes, in narrow drainageways. In a few areas gullies are active and cannot be crossed with farm machinery.

Organic-matter content is low, and the surface layer is in poor tilth. These soils are sticky when wet and

become hard and cloddy when they dry. Water infiltration is slow, and runoff is rapid.

These soils are better suited to permanent vegetation than to crops, because the hazard of erosion is very severe. (Capability unit VIIe-1; woodland suitability group 7)

Keswick-Lindley loams, 14 to 18 percent slopes, moderately eroded (KyE2).—These soils are similar to Keswick loam, 9 to 14 percent slopes, moderately eroded, but they have a slightly thinner clay subsoil. They occur in a contour pattern below the strongly sloping Clinton soils and above the steep or very steep Lindley soils. Some areas are above Nodaway-Martinsburg silt loams, 2 to 5 percent slopes, and some are above Radford-Ely, complex, 2 to 5 percent slopes, in narrow drainageways.

Included with these soils in mapping are areas where the surface layer is slightly darker and small areas where the reddish-brown subsoil is exposed.

Much of the acreage of this complex has been cleared of trees and is used for permanent pasture. A few areas are used for crops, but these soils are not suited to crops. Areas cleared of trees are better suited to permanent hay or pasture. Because of the severe erosion hazard, these soils should be worked only as much as needed to establish new seedlings. These soils are acid unless recently limed, and seedlings respond well to lime. (Capability unit VIe-1; woodland suitability group 7)

Koszta Series

The Koszta series consists of somewhat poorly drained soils that developed from silty alluvium under a mixed grass and tree vegetation. These soils are on low stream benches along the major streams and their tributaries. They occur closely with the Watkins, Vesser, Chequest, and Amana soils. Slopes range from 1 to 3 percent.

In a typical profile the surface layer is very dark gray and very dark grayish-brown silt loam 7 inches thick. The subsurface layer, about 13 inches thick, is very dark gray and dark grayish-brown silt loam. This layer is distinctly light-colored when dry and is mixed into the plow layer in places. The subsoil is friable and firm silty clay loam that extends to a depth of 68 inches. It is dark gray and dark grayish brown to grayish brown in the upper part and is gray below a depth of about 34 inches. Yellowish-brown, strong-brown, and olive-brown mottles occur throughout the subsoil.

Koszta soils have a high available moisture holding capacity and moderately slow permeability. The surface layer is neutral to strongly acid, and the subsoil typically is strongly acid in the upper part but ranges to neutral in the lower part. Koszta soils are commonly low in available nitrogen, phosphorus, and potassium.

Typical profile of Koszta silt loam, 80 feet west of the northeast corner of SW¼ of section 33, T. 75 N., R. 10 W., in a soybean field on a slope of 2 percent that faces west:

Ap—0 to 7 inches, very dark gray (10YR 3/1) and very dark grayish-brown (10YR 3/2) silt loam; few, fine, faint mottles of dark grayish brown and brown; cloddy to weak, fine, granular structure; friable; few fine concretions of iron and manganese; slightly acid; clear boundary.

A21—7 to 15 inches, very dark gray (10YR 3/1) and dark grayish-brown (10YR 4/2) silt loam, dark grayish brown (10YR 4/2) when kneaded; few, fine, distinct mottles of yellowish brown (10YR 5/6); weak, medium, platy structure that breaks to moderate, fine, granular structure; friable; common fine concretions of iron and manganese; strongly acid; clear, smooth boundary.

A22—15 to 20 inches, dark grayish-brown (10YR 4/2) silt loam; few, fine, distinct mottles of dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6); weak, medium, platy structure that breaks to moderate, fine, granular structure; friable; common fine concretions of iron and manganese; strongly acid; clear, smooth boundary.

B1—20 to 26 inches, dark-gray (10YR 4/1) and dark grayish-brown (10YR 4/2) light silty clay loam; few, fine, prominent mottles of strong brown (7.5YR 5/6) and few, fine, distinct mottles of yellowish brown (10YR 5/4); weak, fine, subangular blocky structure; friable; few fine concretions of manganese and common fine concretions of iron; medium acid; clear, smooth boundary.

B2t—26 to 34 inches, grayish-brown (2.5Y 5/2) medium silty clay loam; common ped coating, light gray (10YR 7/1) when dry; few, fine, prominent mottles of strong brown (7.5YR 5/6); moderate, medium, prismatic structure that breaks to moderate, fine, subangular blocky structure; firm; few, thin, discontinuous clay films; common fine concretions of iron and few fine and medium concretions of manganese; medium acid; clear, smooth boundary.

B31t—34 to 53 inches, gray (5Y 5/1) silty clay loam; few ped coatings, light gray (10YR 7/1) when dry; few, fine, prominent mottles of strong brown (7.5YR 5/6) and olive brown (2.5Y 4/4); strong, medium, prismatic structure that breaks to moderate, coarse, subangular blocky structure; firm; thin patchy clay films on peds and few black (10YR 2/1) clay fills in old root channels; common fine concretions of iron and manganese and few manganese stains; few pebbles; slightly acid; clear, smooth boundary.

B32—53 to 68 inches, gray (5Y 5/1) medium silty clay loam; few, fine, prominent mottles of strong brown (7.5YR 5/6) and yellowish brown (10YR 5/6); massive (structureless) but has some vertical cleavage; firm; few black (10YR 2/1) clay fills in old root channels; common fine concretions of iron and manganese; neutral.

In undisturbed areas the A1 horizon ranges from 6 to 10 inches in thickness and from black to very dark grayish brown in color. The A2 horizon, which ranges from very dark gray to grayish brown, is mixed into the plow layer in places. The B horizon has an average clay content of less than 35 percent. These soils are leached of carbonates to a depth of 60 inches or more and are strongly acid in the most acid part of the profile.

Koszta soils are more poorly drained than Watkins soils and have grayer colors in the subsoil. They do not have so high a clay content as Tuskeego soils. They have a thinner, lighter colored surface layer and a thinner subsurface layer than the Vesser soils and are shallower to the silty clay loam subsoil. Koszta soils have a thinner surface layer than the Amana and Chequest soils, which do not have an A2 horizon.

Koszta silt loam, 1 to 3 percent slopes (KzA).—This soil has a very dark gray or very dark brown surface layer 6 to 10 inches thick. It is underlain by a moderately well developed silty clay loam subsoil that is moderately slowly permeable. The subsoil is distinctly mottled with yellowish brown and olive brown.

This soil is on moderately wide second bottoms that are slightly higher than the adjacent first bottoms. Because of this position, flooding from rivers is only occasional in most areas. Some areas adjacent to foot slopes receive runoff from uplands. This soil occurs closely with Watkins and Chequest soils. It is slightly lower on the landscape than Watkins soils and a little higher than Chequest

soils. Many areas are on low benches surrounded by Colo, Wabash, or Amana soils of the first bottoms.

Included with this soil in mapping are small areas of soils that are both darker colored and lighter colored than this Koszta soil.

Because this soil is fertile, has a friable surface layer, and generally is in good tilth, it is used intensively for row crops. It is well suited to corn, soybeans, and small grains and to forage grasses and legumes. Since this soil is somewhat poorly drained, artificial drainage is required for maximum production. Tile lines function well. Additions of lime are needed for good crop growth. (Capability unit I-1; woodland suitability group 4)

Ladoga Series

The Ladoga series consists of moderately well drained soils that developed from loess under a native vegetation of mixed prairie grass and trees. These soils are on convex ridgetops and side slopes in uplands and on stream benches along the major rivers in the county. Slopes range from 2 to 14 percent.

In a typical profile the surface layer is very dark gray to very dark grayish-brown silt loam about 8 inches thick. The subsurface layer, about 6 inches thick, is dark grayish-brown silt loam that is distinctly light colored when dry. The subsoil, which extends to a depth of 42 inches, is mainly brown, firm silty clay loam. The underlying material is mottled yellowish-brown and gray light silty clay loam.

Ladoga soils have a high available moisture holding capacity and are moderately slowly permeable. The surface layer is slightly acid to medium acid, the subsurface is typically medium acid, the subsoil is strongly acid to medium acid, and the substratum is medium acid to slightly acid. Ladoga soils are low in available nitrogen and available phosphorus and low to medium in available potassium.

Typical profile of Ladoga silt loam, 760 feet east and 200 feet north of the southwest corner of the SE¼ section 19, T. 77 N., R. 11 W., on a convex slope of 3 percent on a ridgetop that faces north:

A1—0 to 8 inches, very dark gray (10YR 3/1) and very dark grayish-brown (10YR 3/2) silt loam, very dark grayish brown (10YR 3/2) when kneaded; very weak, thin, platy structure that breaks to moderate, fine, granular structure; friable; nearly continuous grainy coats that are light-gray (10YR 7/2) when dry; few, fine, soft concretions of dark-brown and black oxides; slightly acid; clear, smooth boundary.

A2—8 to 14 inches, dark grayish-brown (10YR 4/2) heavy silt loam, dark grayish brown (10YR 4/2) when kneaded; few, fine, faint mottles of dark brown to brown (10YR 4/3); weak, thin, platy structure that breaks to moderate, fine, granular structure; friable; some discontinuous very dark gray (10YR 3/1) coatings on peds; nearly continuous grainy coats that are light gray (10YR 7/2) when dry; few fine concretions of black and strong-brown oxides; medium acid; clear, smooth boundary.

B21t—14 to 20 inches, medium silty clay loam that has brown (10YR 4/3) ped exteriors and dark yellowish-brown (10YR 4/4) ped interiors; strong, fine, subangular blocky structure; firm; few, thin, patchy clay films; discontinuous grainy coats that are light gray (10YR 7/2) when dry; few fine concretions of black and strong-brown oxides; strongly acid; clear, smooth boundary.

B22t—20 to 33 inches, heavy silty clay loam and medium silty clay loam that have brown (10YR 4/3) ped exteriors and yellowish-brown (10YR 5/4) ped interiors; very few, fine, distinct mottles of olive gray (5Y 5/2); moderate, fine, subangular blocky structure; firm; thin continuous clay films; discontinuous grainy coats that are light gray (10YR 7/2) when dry; few, fine concretions of black and strong-brown oxides; strongly acid; clear, smooth boundary.

B3t—33 to 42 inches, light silty clay loam that has brown (10YR 5/3) ped exteriors and yellowish-brown (10YR 5/4) ped interiors; weak, fine and medium, subangular blocky structure; common, fine, distinct mottles of olive gray (5Y 5/2); firm; thin discontinuous clay films; horizontal band of discontinuous grainy coats that are light gray (10YR 7/2) when dry; many fine concretions of black and strong-brown oxides; medium acid; gradual, smooth boundary.

C—42 to 54 inches, mottled yellowish-brown (10YR 5/4) and gray (5Y 5/1) light silty clay loam; few, fine, distinct mottles of strong brown (7.5YR 5/6); massive (structureless) but some vertical cleavage; firm; many fine concretions of black and strong-brown oxides; medium acid.

The A1 horizon is very dark gray, very dark brown, or very dark grayish-brown silt loam 4 to 8 inches thick. The A2 horizon, where present, ranges from very dark grayish brown to dark grayish brown in color and from 2 to 6 inches in thickness. The B horizon ranges from dark brown to brown to yellowish brown. In some places grayish mottles are as little as about 2 feet from the surface. Texture of the B horizon ranges from medium silty clay loam to very light silty clay that is 35 to 42 percent clay. These soils are leached to a depth of 60 inches or more and are medium acid to strongly acid in the most acid part.

Ladoga soils have a thinner, less clayey surface layer than Otley soils and in places a distinct grayish subsurface layer that the Otley soils lack. Ladoga soils have a thicker and darker colored surface layer than Clinton soils, and a less distinct subsurface layer. They lack the olive-gray colors that occur at a depth of 24 to 36 inches in the Nira soils.

Ladoga silt loam, 2 to 5 percent slopes (LaB).—This moderately well drained soil occurs on moderately wide, rounded upland divides and on side slopes. It is below the somewhat poorly drained Givin soils and normally is above the moderately sloping Ladoga soils. Some areas are above the Clarinda or Lamoni soils or Colo-Ely silty clay loams, 2 to 5 percent slopes.

The profile of this soil is that described as typical for the series. Permeability is moderately slow, organic-matter content is medium, and the erosion hazard is slight.

Included with this soil in mapping are areas of nearly level soils, on upland ridgetops or divides, that have a thicker surface layer than the Ladoga soils. Also included, at the heads of drainageways, are small areas of soils that are less well drained and have a gray subsoil. In very narrow natural drainageways, soils are included that have a thicker and darker surface layer.

This Ladoga soil is used intensively for row crops and is well suited to corn, soybeans, small grains, forage grasses, and legumes. Tilth generally is good, and if it becomes poor, additional meadow crops can be grown. Since this soil is normally acid, additions of lime are beneficial. (Capability unit IIe-1; woodland suitability group 1)

Ladoga silt loam, 5 to 9 percent slopes (LaC).—This soil has a very dark gray to very dark grayish-brown surface layer 4 to 8 inches thick and a very dark gray and very dark grayish-brown subsurface layer 2 to 6 inches thick. The dark-brown to yellowish-brown subsoil

is moderately slowly permeable. Content of organic matter is medium, and the hazard of erosion is moderate.

This soil is on rounded upland divides and side slopes, generally below the gently sloping Ladoga soils and above the more strongly sloping Ladoga, Adair, Clarinda, and Lamoni soils or Colo-Ely silty clay loams, 2 to 5 percent slopes. On side slopes that extend toward broad divides, this soil is generally associated with Otley soils.

Included with this soil in mapping some areas are small spots of a sandy soil. Also included, on the ridgetops, are areas of gently sloping soils and, at the heads of waterways, small areas of soils that are not so well drained as Ladoga soils. Other included soils are seasonally wet and seepy and have a gray subsoil and, in very narrow drainageways, soils that have a thicker and darker surface layer than Ladoga soils.

This soil is used for pasture and row crops. Although the erosion hazard is moderate, row crops grow well without excess soil loss where this soil is terraced and tilled on the contour. Since it is normally acid, lime is needed for best crop growth. (Capability unit IIIe-1; woodland suitability group 1)

Ladoga silt loam, 5 to 9 percent slopes, moderately eroded (LaC2).—This soil is similar to Ladoga silt loam, 5 to 9 percent slopes, except that the surface layer is thinner and browner. In most places the grayish subsurface layer has been mixed with the surface layer to form a very dark grayish-brown plow layer 5 to 7 inches thick. The dark-brown to yellowish-brown subsoil is moderately slowly permeable.

This soil is on rounded ridgetops and in narrow bands on side slopes. It is the most extensive Ladoga soil in the county, and individual acreages are large. It occurs below the gently sloping Ladoga soils and above the more strongly sloping Ladoga, Adair, Clarinda, and Lamoni soils or Colo-Ely silty clay loams, 2 to 5 percent slopes. It occurs with Otley soils on side slopes that extend toward broad divides and with Clinton soils on slopes that extend toward more dissected areas. In some areas it is associated with Dickinson and Sparta soils.

Small sand spots are included with this soil in mapping and are shown on the soil map by the symbol for sand. Included at heads of drainageways, are small areas that are not so well drained as the Ladoga soils. Also included are seasonally wet and seepy soils that have a gray subsoil and, in the very narrow drainageways, soils that have a thicker and darker surface layer.

Nearly all of this soil is in crops. Where it is terraced and tilled on the contour to control erosion, this soil is well suited to row crops, small grains, and hay. This soil is acid unless recently limed, and lime is needed for good crop growth. (Capability unit IIIe-1; woodland suitability group 1)

Ladoga silt loam, 9 to 14 percent slopes (LaD).—This soil is similar to Ladoga silt loam, 5 to 9 percent slopes, except that it is steeper. On strong side slopes below other Ladoga soils, it generally occurs in bands, which are broken in many places. It is above or adjacent to Adair, Clarinda, Lamoni, or Gara soils and above Colo-Ely silty clay loams, 2 to 5 percent slopes. In some areas it occurs with Dickinson-Sparta complex, 2 to 5 percent slopes.

Small spots of sand are included with this soil in mapping and are shown on the soil map by the symbol for sand. Also included, near the heads of drainageways, are seasonally wet and seepy soils that have a gray subsoil and, in narrow drainageways, soils that have a thicker and darker surface layer than Ladoga soils.

Most of this soil is in small pastures, some is in trees, and the rest is in crops. Because runoff is rapid and the hazard of erosion is severe, management is needed to control erosion. If erosion is controlled, this soil is fairly well suited to row crops. This soil is acid unless recently limed, and lime is needed for good crop growth. (Capability unit IIIe-1; woodland suitability group 1)

Ladoga silt loam, 9 to 14 percent slopes, moderately eroded (LaD2).—The surface layer of this soil is thinner and lighter colored than that described as typical for the series. In most places the original surface and subsurface layers have been mixed with some of the subsoil to form a very dark grayish-brown plow layer 5 to 7 inches thick. The subsoil is dark brown to yellowish brown.

This soil normally is in bands, some broken, on side slopes below other Ladoga soils. It occurs above or adjacent to Adair, Clarinda, Lamoni, or Gara soils and above Colo-Ely silty clay loams, 2 to 5 percent slopes. In some areas it is associated with Dickinson-Sparta complex, 2 to 5 percent slopes.

Small spots of sand are included with this soil in mapping and are shown on the soil map by the symbol for sand. Also included, near the heads of drainageways, are seasonally wet and seepy soils that have a gray subsoil and, in the narrow drainageways, soils that have a thicker and darker surface layer than Ladoga soils.

This soil is mostly used for crops, and it is moderately well suited to them. Individual areas are commonly 12 to 15 acres in size. These areas are often farmed with other soils occurring on the same slopes. Some areas are farmed with the moderately sloping Ladoga soils upslope. Since runoff is rapid and the surface layer is erodible, this soil should be protected from erosion by terraces and tilled on the contour. Tilth is often poor, but it can be improved by growing meadow crops for an additional year or by applying manure. This soil is acid unless limed, and lime is needed for good crop growth. (Capability unit IIIe-1; woodland suitability group 1)

Ladoga silt loam, benches, 2 to 5 percent slopes (LbB).—This soil has a profile similar to that described as typical for the series. It occurs on gently sloping loess-covered benches along river bottoms and on moderately wide benches that break abruptly from strongly sloping uplands. These benches are underlain by alluvium at a depth of 10 to 15 feet. This soil is below Givin soils and usually above moderately sloping Ladoga or Clinton soils.

Included with this soil in mapping are areas of somewhat poorly drained soils and small areas having slopes of less than 2 percent.

This soil is used intensively for row crops. It is well suited to corn, soybeans, small grains, forage grasses, and legumes. Where row crops are grown, tilling should be on the contour to reduce soil losses. The slope pattern is irregular, however, and contour tillage is difficult. Tilth is generally good, but if it becomes poor more meadow crops should be grown. The content of organic matter is medium. This soil benefits from additions of lime. (Capability unit IIe-1; woodland suitability group 1)

Ladoga soils, 5 to 9 percent slopes, severely eroded (LdC3).—These soils have a brown or dark yellowish-brown silty clay loam plow layer that is mostly subsoil mixed with a small amount of the surface and subsurface layers. The subsoil is dark brown to yellowish brown.

These soils are on rounded ridgetops and in narrow bands on side slopes. They are small in extent and normally occur within gently sloping or nearly level fields that are used intensively for row crops.

Included with these soils in mapping, at the heads of drainageways, are small areas that are not so well drained. Also included are seasonally wet and seepy soils that have a gray subsoil and, in the very narrow drainageways on side slopes, soils that have a thicker and darker surface layer than Ladoga soils.

These soils are used almost entirely for crops. Although the erosion hazard is severe, they are moderately well suited to row crops if fields are terraced and tilled on the contour.

Tilth is poor in many places, but it can be improved by growing more meadow crops and by applying barnyard manure. These practices also help in controlling erosion. This soil is acid unless limed, and lime is needed for good crop growth. (Capability unit IIIe-1; woodland suitability group 1)

Ladoga soils, 9 to 14 percent slopes, severely eroded (LdD3).—These soils have a plow layer of brown or dark yellowish-brown silty clay loam 5 to 7 inches thick. It consists of subsoil mixed with a small amount of the surface and subsurface layers. The subsoil is dark brown to yellowish brown and is moderately slowly permeable.

These soils occur in bands, broken in places, on strong side slopes below other Ladoga soils. They are above or adjacent to Adair, Clarinda, Lamoni, or Gara soils and above Colo-Ely silty clay loams, 2 to 5 percent slopes. In some areas they are associated with Dickinson-Sparta complex, 2 to 5 percent slopes.

Small areas of sand are included with these soils in mapping. Also included, near the heads of drainageways, are seasonally wet and seepy soils that have a gray subsoil. In the narrow drainageways on side slopes, soils are included that have a thicker and darker surface layer than the Ladoga soils. In a few gullied areas, the surface layer between gullies is very dark grayish-brown silt loam, 3 to 6 inches thick.

Most areas of these soils are in crops, but pasture and hay would be more suitable because tilth is poor. The erosion hazard is severe.

Where these soils are in row crops, they should be protected from further erosion by terracing and tilling on the contour. Applications of manure help to improve tilth. In areas where the subsoil is exposed, it is difficult to plow and to prepare seedbeds. These soils are acid unless recently limed, and they need lime for good crop growth. (Capability unit IVe-1; woodland suitability group 1)

Lamoni Series

The Lamoni series consists of somewhat poorly drained soils of the uplands that developed from remnants of a buried clayey soil that formed from weathered glacial till. Lamoni soils have convex slopes of 5 to 18 percent. They occur as bands at the shoulders of slopes and in coves at the upper reaches of drainageways below loess-derived Otley and Ladoga soils and below Clarinda soils that developed from weathered glacial till. On some steep slopes, Lamoni soils are closely associated with Shelby soils.

In a typical profile the surface layer is very dark brown and very dark grayish-brown silty clay loam about 11 inches thick. The subsoil extends to a depth of 53 inches or more. It is dark grayish-brown silty clay loam to a depth of 15 inches, dark grayish-brown to olive clay to a depth of 29 inches, mottled yellowish-brown, light olive-brown, and olive-gray clay loam to a depth of 38 inches, and is light olive-gray clay loam in the lowest part. The subsoil is mottled with dark yellowish brown, yellowish brown, light olive brown, and strong brown. Many small rock fragments and pebbles are present.

Lamoni soils are very slowly permeable and have a high available moisture holding capacity. The surface layer is neutral to medium acid, the upper subsoil typically is medium acid, and the lower subsoil and the substratum are slightly acid to neutral. Uneroded areas are low in available nitrogen, very low in available phosphorus, and low to medium in available potassium. Eroded areas are very low in available nitrogen.

Typical profile of Lamoni silty clay loam, 1,000 feet east and 210 feet south of the northwest corner of the NE1/4 section 13, T. 76 N., R. 11 W., in a cultivated field on a slope of 9 percent that faces northwest:

Ap—0 to 7 inches, very dark brown (10YR 2/2) to very dark grayish-brown (10YR 3/2) light silty clay loam; few, fine, faint mottles of brown (10YR 4/3); weak, fine, granular structure; friable; few, fine, sand grains; few, very fine, soft concretions of a strong-brown oxide; neutral; abrupt, smooth boundary.

A3—7 to 11 inches, very dark grayish-brown (10YR 3/2) medium silty clay loam, very dark grayish brown (10YR 3/2) when kneaded; common, fine, faint mottles of brown (10YR 4/3); weak, very fine, subangular blocky and moderate, fine, granular structure; firm; few, fine, moderately hard concretions of a strong-brown oxide; common grains of clear quartz on ped faces; medium acid; clear, smooth boundary.

B1t—11 to 15 inches, dark grayish-brown (10YR 4/2) heavy silty clay loam; few, fine, faint mottles of dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6); moderate, fine and very fine, subangular blocky structure; firm; common, thin, discontinuous clay films; common, very fine, soft concretions of a strong-brown oxide; common clear quartz grains on ped faces; medium acid; gradual, smooth boundary.

IIB21t—15 to 21 inches, dark grayish-brown (10YR 4/2) and grayish-brown (2.5Y 5/2) clay; common, fine, faint mottles of light olive brown (2.5Y 5/5); moderate, very fine, subangular blocky structure; firm; common, thin, discontinuous clay films; common, very fine, soft concretions of a strong-brown oxide; common clear quartz grains on ped faces; few small pebbles; medium acid; clear, smooth boundary.

IIB22t—21 to 29 inches, mottled gray (5Y 5/1), olive-gray (5Y 5/2), and olive (5Y 5/3) clay; many, fine, distinct mottles of yellowish brown (10YR 5/8); weak, medium, prismatic breaking to weak, fine subangular blocky structure; very firm; common, thin, continuous clay films; few dark-gray (5Y 3/1) clay fills in old root channels; common, very fine, soft concretions of strong-brown and black oxides; common clear quartz grains on ped surfaces; few small stones and pebbles; medium acid; gradual, smooth boundary.

IIB23t—29 to 38 inches, mottled yellowish-brown (10YR 5/6), light olive-brown (2.5Y 5/4), and olive-gray (5Y 5/2) heavy clay loam; weak, medium, prismatic

structure that breaks to weak, fine and medium, subangular blocky structure; firm; common, thin to medium, continuous clay films; few very dark gray clay fills in old root channels; common, fine, moderately hard concretions of strong-brown and black oxides; common grains of clear quartz on ped faces; many pebbles and small stones; neutral; gradual, smooth boundary.

IIB3t—38 to 53 inches, light olive-gray (5Y 6/2) medium clay loam; common, fine, prominent mottles of yellowish brown (10YR 5/8) and strong brown (7.5YR 5/6); weak, medium, prismatic structure that breaks to weak, medium, subangular blocky structure; firm; common, thin, continuous clay films and a few, medium, discontinuous clay films; a few dark-gray (10YR 4/1) clay fills in old root channels; few, fine, moderately hard concretions of strong-brown and black oxides; common grains of clear quartz; many small white stones, other rock fragments, and pebbles; a few pebbles about a quarter inch in diameter; neutral; clear, smooth boundary.

The A horizon typically is silty clay loam, but it ranges to clay loam. The A1 or Ap horizon ranges from very dark gray or very dark brown to very dark grayish brown. The clay layer at the upper part of the B horizon ranges from about 6 to 20 inches in thickness. Its maximum clay content is 40 to 50 percent, but clay content decreases with increasing depth. Clay loam is the dominant texture of the lower part of the B horizon, and the content of sand and small pebbles increases with increasing depth. Reaction is medium acid to strongly acid in the most acid part of the profile.

Lamoni soils contain more pebbles and stones and have a thinner and less clayey subsoil than Clarinda soils and are browner in the upper part of the subsoil. The total thickness of the clay or silty clay is about 20 inches or less in Lamoni soils and from 2 to several feet in Clarinda soils. The subsoil of the Lamoni soils is somewhat grayer and contains more clay than that of the Shelby soils. Lamoni soils have a less reddish subsoil than Adair soils.

Lamoni silty clay loam, 5 to 9 percent slopes, moderately eroded (LmC2).—This soil ocurs in bands or strips in a contour pattern, commonly just below the loess-till contact line. It has the profile described as typical for the series. In many places it is upslope from Adair soils, and normally it is above the more strongly sloping Shelby or Gara soils on side slopes, or is above Colo-Ely silty clay loams, 2 to 5 percent slopes, or Radford-Ely complex, 2 to 5 percent slopes, in narrow drainageways.

Small areas of these two complexes in drainageways are included in mapping. Also included are soils that have a thicker, darker surface layer than this Lamoni soil and soils that have a grayer plow layer and contain more clay. In places the grayish clay occurs at a depth of about 3 feet and is overlain by loamy sediment 10 to 20 inches thick. These included soils are mainly at the heads of upland drainageways.

This soil is nearly all in row crops, but it is poorly suited to them. It is moderately well suited to hay or pasture. Because this soil normally is in poor tilth and is difficult to work, crops do not grow well and often are yellow.

In many areas land use is determined by that of the adjoining soils. Where this soil is cultivated, it should be protected by terraces, tilled on the contour, and kept in meadow at least half the time. The terraces, however, should be constructed above or below this Lamoni soil because it has a clayey subsoil. This very slowly permeable soil stays wet longer in spring and after rains than the adjoining soils. Upon drying, the surface becomes hard and cloddy and cracks appear that extend into the subsoil. Seepage and surface wetness can be reduced by placing interceptor tile drains in the more permeable loessal soils upslope. Tile lines do not function well in this soil. (Capability unit IIIe-2; woodland suitability group 8)

Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded (LmD2).—This soil normally has a very dark grayish-brown plow layer 5 to 7 inches thick. The upper part of the subsoil commonly is mottled grayish-brown or olive-gray clay, 1½ to 2 feet thick, that grades to a mottled clay loam with increasing depth.

This soil occurs in bands or strips in a contour pattern, commonly just below the loess-till contact line. It is generally below the moderately sloping Otley, Ladoga, or Clarinda soils. It is above the Gara or Shelby soils on side slopes and above Adair soils, Colo-Ely silty clay loams, 2 to 5 percent slopes, or Radford-Ely complex, 2 to 5 percent slopes, in narrow drainageways.

Small areas of these two complexes in drainageways are included in mapping. Also included are soils that have a thicker, darker surface layer than this Lamoni soil and soils that have a grayer plow layer and contain more clay. In places the grayish clay occurs at a depth of about 3 feet and is overlain by loamy sediment 10 to 20 inches thick. These included soils are mainly at the heads of drainageways.

This soil is nearly all in row crops, but it is poorly suited to them. It is moderately well suited to hay or pasture.

Where it is cultivated, this soil should be protected from erosion by terraces and contour tillage and should not be planted to row crops too often. Because this soil has a fine-textured subsoil, terraces should be constructed in the soils above or below. Since it is very slowly permeable, this soil stays wet longer in spring and following rains than the adjoining soils. The clayey surface layer of this soil is sticky when wet and hard, cloddy, and cracked when dry; cracks extend into the subsoil. Seepage and surface wetness can be reduced by placing interceptor tile drains in the more permeable loessal soils upslope because they dry faster than this soil. Tile lines do not function well when placed in this Lamoni soil. (Capability unit IVe-2; woodland suitability group 8)

Lamoni soils, 9 to 14 percent slopes, severely eroded (LnD3).—These soils have a dark-brown to olive-brown heavy silty clay loam or clay loam plow layer 5 to 7 inches thick. It consists mostly of subsoil mixed with a small amount of the remaining surface layer. The upper part of the subsoil is highly mottled grayish-brown or olive-gray clay or heavy clay loam 1½ to 2 feet thick. It grades to a mottled clay loam in the lower part of the subsoil.

These soils occur in bands or strips in a contour pattern, in many places just below the loess-till contact line. They generally are below the moderately sloping Otley, Ladoga, or Clarinda soils and above the Gara and Shelby soils on side slopes. Other areas occur above Colo-Ely silty clay loams, 2 to 5 percent slopes, or Radford-Ely complex, 2 to 5 percent slopes, in narrow drainageways.

Small areas of these two complexes in narrow drainageways are included in mapping. Also included are a few areas that have a slightly darker surface layer than this Lamoni soil.

Nearly all of the acreage of these soils is in row crops or left idle, though cultivated crops are not suited. These soils are better suited to permanent hay or pasture and wildlife plantings. Birdsfoot trefoil is a well-suited legume.

A good stand of seedlings is difficult to obtain because the clayey surface layer is sticky when wet and hard and cloddy when dry, and cracks extend into the subsoil. Mulching the surface with manure is helpful. Seepage can be controlled by interceptor tiles installed in the loess-derived soils upslope. (Capability unit VIe–1; woodland suitability group 8)

Lamoni-Shelby complex, 14 to 18 percent slopes, moderately eroded (LoE2).—The soils of this complex are so closely intermingled that they are not mapped separately. The Lamoni soils occur on the upper part of the slopes and have a very dark grayish-brown silty clay loam to heavy clay loam plow layer 5 to 7 inches thick. Shelby soils occur on the lower part of the slopes and have a plow layer that is very dark grayish brown to brown. The subsoil is generally yellowish-brown clay loam. In the Lamoni soils, the subsoil is very slowly permeable, and in the Shelby soils it is moderately slowly permeable. The Lamoni and Shelby soils are about equal in extent within this mapping unit.

The soils of this complex occur on irregular slopes, normally below moderately sloping to strongly sloping Lamoni, Otley, or Ladoga soils. A few areas occur above more strongly sloping Shelby or Gara soils. This complex generally is above Colo-Ely silty clay loams, 2 to 5 percent slopes, and Radford-Ely complex, 2 to 5 percent slopes, in narrow drainageways, and small areas of these two complexes are included in mapping. Also included are eroded areas where the gray subsoil is exposed.

Most of the soils of this complex are in row crops, but some areas are in pasture. These soils are not suited to row crops but are better suited to semipermanent hay or pasture. Tilth commonly is poor, and the hazard of erosion is very severe. (Capability unit VIe–1; woodland suitability group 8)

Lamont Series

The Lamont series consists of well-drained to somewhat excessively drained soils. These soils developed from fine and medium sand deposits that have been reworked by wind. The native vegetation was trees. Lamont soils are on convex ridges and side slopes and on stream benches adjacent to the major river valleys. Slopes range from 5 to 30 percent and are irregular and complex in many places. Lamont soils are closely intermingled with the Clinton and Chelsea soils and are mapped with them as a complex.

In a typical profile the surface layer of Lamont soils is dark grayish-brown or brown fine sandy loam about 7 inches thick. The subsoil extends to a depth of about 40 inches. It is brown and yellowish-brown, friable sandy loam to loam to a depth of 20 inches; yellowish-brown, very friable sandy loam to loamy sand to a depth of 36 inches; and strong-brown, loose loamy fine sand in 2-inch bands, and interbands of light yellowish-brown sand, to a depth of 40 inches. The underlying material is yellowish-brown fine sand.

Lamont soils have a low available moisture holding capacity and are rapidly permeable. The surface layer is neutral to slightly acid, the subsoil is medium to strongly acid, and the substratum is neutral to slightly acid. These soils are typically very low in available nitrogen, medium in available phosphorus, and very low in available potassium.

Typical profile of Lamont fine sandy loam, 400 feet east and 900 feet south of the northwest corner of the SW¼SE¼ section 24, T. 75 N., R. 11 W., on a convex side slope of 11 percent facing south:

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) to brown (10YR 4/3) fine sandy loam; weak, fine, subangular blocky structure; very friable; slightly acid; abrupt, smooth boundary.

B1—7 to 13 inches, dark yellowish-brown (10YR 4/4) and dark grayish-brown (10YR 4/2) fine sandy loam; weak, fine, subangular blocky structure; very friable; medium acid; clear, smooth boundary.

B2t—13 to 20 inches, fine sandy loam to loam that has brown (10YR 4/3) ped exteriors and yellowish-brown (10YR 5/4) ped interiors; weak, fine, subangular blocky structure; friable; thin discontinuous clay films; medium acid; clear, smooth boundary.

B31—20 to 36 inches, yellowish-brown (10YR 5/4 and 5/6) sandy loam to loamy fine sand; weak, medium to coarse, subangular blocky structure; very friable; medium acid; clear, smooth boundary.

B32—36 to 40 inches, strong-brown (7.5YR 5/6) loamy fine sand, in 2-inch bands, and interbands of light yellowish-brown (10YR 6/4) sand; some vertical cleavage; loose; few, fine, moderately hard concretions of a black oxide; medium acid; gradual, wavy boundary.

C—40 to 57 inches, yellowish-brown (10YR 5/6) fine sand; single grain; loose; slightly acid.

The A1 horizon ranges from 4 to 8 inches in thickness where Lamont soils are not eroded. It ranges from dark brown to dark grayish brown in color and from sandy loam to loamy sand in texture. Thin bands of clay and iron occur in the lower part of the B horizon and in the substratum. These bands are less than 1 to 5 inches wide and are wavy and typically discontinuous. They have a higher content of clay and redder colors than the material between them. These soils are leached of carbonates to a depth of several feet and range from slightly acid to strongly acid in the most acid part.

Lamont soils have a lighter colored, thinner surface layer than Dickinson soils. The subsoil of Lamont soils is less sandy than that of Chelsea soils, which have a structureless instead of weakly developed subsoil.

Lamont-Clinton-Chelsea complex, 5 to 9 percent slopes, moderately eroded (LpC2).—The soils of this complex have a dark grayish-brown surface layer. The moderately well drained Clinton soils have a silt loam surface layer and silty clay loam subsoil and developed from loess under trees. Chelsea soils developed from windblown sand under trees. They are sandy throughout, rapidly permeable, and excessively drained. Lamont soils also developed from windblown sand under trees. They normally have a fine sandy loam surface layer and a fine sandy loam to light sandy clay loam subsoil. They are rapidly permeable and well drained to somewhat excessively drained.

This complex is on side slopes or rounded ridgetops that extend into more dissected areas. It occurs closely with sloping Clinton and Chelsea soils on the same or adjacent slopes or ridgetops. Some areas are on stream benches, normally with Clinton soils, and are underlain by alluvium at a depth of 10 to 25 feet.

Included with this complex in mapping are upland areas that are predominantly sandy throughout; small sand blowouts are common on ridgetops. A few sandy areas also occur on foot slopes. Also included are a few areas that have a slightly thicker and darker surface layer than is normal for the complex. Some areas on ridgetops have slopes of less than 5 percent.

The soils of this complex generally are used for row crops, but some areas are in pasture. A small acreage is in trees. These soils are moderately well suited to row crops but are better suited to forage grasses and legumes.

Because water erosion and soil blowing are moderate hazards on these soils, practices of erosion control are needed. The soils should be tilled on the contour where row crops are grown. Applications of manure improve water-holding capacity and aid in controlling soil blowing. They also supply some needed nutrients and thus raise the fertility of these soils. These soils require additions of lime if legumes are to be grown. (Capability unit IIIs–1; woodland suitability group 5)

Lamont-Clinton-Chelsea complex, 9 to 14 percent slopes, moderately eroded (LpD2).—The soils of this complex are similar to those of Lamont-Clinton-Chelsea complex, 5 to 9 percent slopes, moderately eroded. They generally occur on side slopes adjacent to the bottom lands that border major streams. They occur closely with Clinton and Chelsea soils, mapped separately, on the same or adjacent slopes. They are below Clinton soils or Lamont-Clinton-Chelsea complex, 5 to 9 percent slopes, on ridgetops. A few areas are above the Boone, Lindley, and other moderately steep soils.

Included with these soils in mapping, in Clear Creek Township and the southern part of Plank Township, are one or two areas where most of the surface layer is sandy loam and where the silt loams and loamy fine sands are lacking. Some areas are severely eroded and have little or no vegetation. Also included, in Clear Creek and Richland Townships, are small areas on stream benches. Areas not cultivated have a thicker and slightly darker surface layer than is normal for cultivated areas.

Many areas of these soils are in row crops, though they are poorly suited to them because of droughtiness and lack of nutrients. These soils are better suited to forage crops and improved pastures than to row crops. They are also suited to trees and plantings for wildlife.

Because the hazard of erosion is severe on these soils, areas used for row crops should be tilled on the contour, though tillage should be minimum. Additions of fertilizer are needed if row crops are grown. Where legumes are grown, additions of lime are needed unless recently applied. (Capability unit IVe–1; woodland suitability group 5)

Lamont-Clinton-Chelsea complex, 14 to 18 percent slopes, moderately eroded (LpE2).—The soils of this complex occur on side slopes bordering major streams, generally above foot slopes and first bottoms and above steep Lindley soils. A few areas occur with Boone soils on steeper slopes. The soils of this complex also occur with those of Lamont-Clinton-Chelsea complex, 5 to 9 percent slopes, moderately eroded, and they are similar to those soils.

Included with these soils in mapping are severely eroded areas that have yellowish-brown silty clay loam or sand exposed at the surface. Also included are a few areas that have a thicker and slightly darker surface layer than the soils in this complex.

These soils are used for trees or permanent pasture. They are better suited to trees and pasture than to row crops. A few areas are in row crops, but they are not suited to them. Where these soils are used for pasture, grazing should be controlled to avoid overgrazing.

Practices are needed to lessen the very severe hazards of water erosion and soil blowing. Also needed are practices to offset droughtiness and to increase fertility. If legumes are grown, additions of lime are needed. In some places stands of trees are difficult to establish. (Capability unit VIe–1; woodland suitability group 5)

Lamont-Clinton-Chelsea complex, 18 to 30 percent slopes, moderately eroded (LpF2).—The soils of this complex are similar to those of Lamont-Clinton-Chelsea complex, 5 to 9 percent slopes, moderately eroded. They occur in upland areas on steep side slopes that border major streams. They are above the soils of the foot slopes and first bottoms and occur closely with soils of Lamont-Clinton-Chelsea complex, 14 to 18 percent slopes, moderately eroded.

Included with these soils in mapping are a few dominantly sandy areas. Also included are a few areas that have a slightly thicker and darker surface layer than the soils in this complex and a few eroded areas where the yellowish-brown sand or silty clay loam subsoil is exposed.

Most of this complex is in trees, but a few areas are in permanent pasture. These soils probably are better suited to trees or to plantings for wildlife than to permanent pasture. Since the Chelsea and Lamont soils are very droughty and very low to low in fertility, it may be difficult to obtain a good stand of trees by planting seedlings. (Capability unit VIIe–1; woodland suitability group 5)

Lindley Series

The soils of the Lindley series developed from clay loam glacial till. They are moderately well drained and contain some pebbles and stones. Lindley soils are on convex upland ridgetops and side slopes along major streams of the county. Slopes range from 9 to 40 percent. These soils occur closely with the Keswick and Clinton soils and are downslope from them. In some places they are mapped with Keswick soils in a complex.

In a typical profile the uneroded surface layer is about 3 inches thick and consists of very dark gray loam. The subsurface layer, 4 inches thick, is brown loam. Both the surface layer and the subsurface layer are distinctly light colored when dry. The subsoil extends to a depth of 50 inches, and is yellowish brown throughout. It is friable loam to a depth of 13 inches, firm clay loam to 33 inches, and firm sandy clay loam to 50 inches. Red, reddish-brown, light brownish-gray, and yellowish-brown mottles occur in this lower part of the subsoil. The underlying material is a mottled yellowish-brown firm sandy clay loam.

Lindley soils are moderately slowly permeable and have a high available moisture holding capacity. The

surface layer is slightly acid to very strongly acid, and the subsurface layer is very strongly acid to medium acid. The subsoil is very strongly acid to extremely acid in the most acid part, and the substratum is slightly acid to neutral. In places carbonates are present in the substratum. Lindley soils are low or very low in available nitrogen, medium in available phosphorus, and very low in available potassium.

Typical profile of Lindley loam, 300 feet east and 100 feet south of the northwest corner of the NW¼SW¼ section 24, T. 76 N., R. 11 W., on an upland side slope of 15 percent that faces northwest:

A1—0 to 3 inches, very dark gray (10YR 3/1) light loam, gray (10YR 5/1) when dry; moderate, fine, granular structure; very friable; many fine roots; very strongly acid; clear, smooth boundary.

A2—3 to 7 inches, brown (10YR 5/3) light loam, light gray (10YR 7/2) when dry; weak, thin and medium, platy structure; very friable; very strongly acid; clear, smooth boundary.

B1—7 to 13 inches, yellowish-brown (10YR 5/4) heavy loam; weak, medium and fine, subangular blocky structure that breaks to moderate, fine and very fine, granular structure; friable; thin, continuous, brown (10YR 5/3) grainy coats; very strongly acid; few pebbles; gradual, smooth boundary.

B21t—13 to 19 inches, yellowish-brown (10YR 5/6) medium clay loam; moderate, fine and very fine, subangular blocky structure; firm; few dark-brown clay films; few grainy coats, gray when dry; extremely acid; few pebbles; gradual, smooth boundary.

B22t—19 to 33 inches, yellowish-brown (10YR 5/4) clay loam; common, fine, faint mottles of yellowish brown and few, fine, faint mottles of pale brown, brownish yellow, and strong brown; moderate, fine and very fine, angular blocky and subangular blocky structure; firm; common, thin, continuous clay films of dark yellowish brown (10YR 4/4) on prism faces; extremely acid; few pebbles and stones; gradual, smooth boundary.

B3t—33 to 50 inches, yellowish-brown (10YR 5/4) heavy sandy clay loam; few, fine, prominent mottles of red (10R 4/6) and reddish brown (5YR 4/3), few, fine, distinct mottles of light brownish gray (2.5Y 6/2), and few, fine, faint mottles of yellowish brown; weak, medium to coarse, prismatic structure that breaks to weak, medium, subangular blocky structure; firm; few, thin, discontinuous clay films; common fine concretions of manganese; very strongly acid in upper part to slightly acid in lower part; few pebbles and stones; gradual, smooth boundary.

C—50 to 58 inches, yellowish-brown (10YR 5/6) sandy clay loam; fine, distinct, yellowish-red (5YR 3/8) mottles; massive; firm; few pebbles and stones; neutral.

The A1 horizon ranges from loam to clay loam in texture and from 3 to 7 inches in thickness. It is very dark gray where thin, but it is typically dark grayish brown where cultivated. Where a very thin mantle of loess covers the glacial till, the surface layer is silt loam. The A2 horizon is incorporated in the plow layer in many places. In some places thin horizons in the B horizon have a clay content of as much as 38 percent. The B horizon ranges from yellowish brown to strong brown and has grayish mottles below a depth of about 24 to 30 inches. Grainy coats are visible in the subsoil when peds are dry. The solum is commonly leached below a depth of 40 inches, but on the steep slopes calcareous material may be only 30 inches from the surface. The solum is extremely acid to very strongly acid in the most acid part.

Lindley soils have a thinner surface layer than Gara soils and a more distinct subsurface layer. The subsoil of Lindley soils is browner and less clayey than that of the Keswick soils.

Lindley loam, 9 to 14 percent slopes, moderately eroded (LrD2).—This soil has a dark grayish-brown to brown plow layer 5 to 7 inches thick. The plow layer consists of the remaining parts of the surface and subsurface layers mixed with a small amount of subsoil. This soil is moderately well drained and low in organic matter. The subsoil normally is yellowish-brown clay loam that is moderately slowly permeable.

This soil occurs on upland side slopes adjacent to the strongly dissected areas of the county. It generally is below the moderately sloping Keswick or Clinton soils and above the more strongly sloping Lindley soils. Slopes are normally convex and relatively short.

Included with this soil in mapping are small areas of Nodaway-Martinsburg silt loams, 2 to 5 percent slopes, and Radford-Ely complex, 2 to 5 percent slopes. The areas are in narrow drainageways. Also included, in the small natural drainageways that extend into the side slopes, are some areas that have a darker and thicker surface layer than this Lindley soil. In some severely eroded included areas, the yellowish-brown clay loam subsoil is exposed.

This soil is mostly in row crops or permanent pasture. It is better suited to permanent improved pasture or hay than to row crops. It is suited to occasional row crops where it is terraced and tilled on the contour. Because slopes are strong or steep and permeability is moderately slow in the subsoil, runoff is rapid and the hazard of erosion is severe. This soil is medium to low in fertility. Additions of lime are beneficial. (Capability unit IVe–3; woodland suitability group 2)

Lindley loam, 14 to 18 percent slopes (LrE).—This soil has a very dark grayish-brown to dark grayish-brown surface layer 2 to 4 inches thick. The subsurface layer is dark-gray to dark grayish-brown loam 2 to 4 inches thick. The subsoil normally is yellowish-brown clay loam that is moderately slowly permeable. This soil is moderately well drained and low in organic-matter content.

This soil occurs on upland side slopes adjacent to the strongly dissected areas of the county. It generally is below the strongly sloping Keswick or Clinton soils and above the more strongly sloping Lindley soils or the soils of the foot slopes or bottoms. A few areas are above the steep Sogn soils. Slopes are normally convex and relatively short.

Included with this soil in mapping, in narrow drainageways, are small areas of Nodaway-Martinsburg silt loams, 2 to 5 percent slopes, and Radford-Ely complex, 2 to 5 percent slopes. Also included, in the small natural drainageways, are soils that have a darker and thicker surface layer than this soil.

This soil is mostly in trees. A few areas are in permanent pasture that has a few scattered trees. Because of the low fertility, steep slope, and severe hazard of erosion, this soil is not suited to row crops. It is better suited to improved pasture. Additions of lime are generally needed to insure good stands of legumes. (Capability unit VIe–1; woodland suitability group 2)

Lindley loam, 14 to 18 percent slopes, moderately eroded (LrE2).—This soil has a dark grayish-brown to brown plow layer 5 to 7 inches thick. The plow layer consists of the remaining surface and subsurface layers mixed with a small amount of subsoil. The subsoil is usually yellowish-brown clay loam that is moderately slowly permeable. This soil is moderately well drained and low in organic-matter content.

This soil is on upland side slopes adjacent to strongly dissected areas of the county. It generally is below the strongly sloping Keswick or Clinton soils and above the more strongly sloping Lindley soils or soils of the foot slopes or bottoms. A few areas are above the steep Sogn soils. Slopes normally are convex and relatively short.

Included with this soil in mapping, in narrow drainageways, are small areas of Nodaway-Martinsburg silt loams, 2 to 5 percent slopes, and Radford-Ely complex, 2 to 5 percent slopes. Also included are some areas that have a darker and thicker surface layer than this soil. In a few areas, the surface layer has been removed by erosion and the yellowish-brown subsoil is exposed.

This soil is in crops or permanent pasture. Because of the low fertility, steep slopes, and severe erosion hazard, it is not well suited to row crops. It is better suited to permanent pasture or trees. Additions of lime normally are needed to insure a good stand of legumes. (Capability unit VIe-1; woodland suitability group 2)

Lindley loam, 18 to 25 percent slopes (LrF).—This soil has a very dark grayish-brown to dark grayish-brown surface layer 1 to 3 inches thick and a dark-gray to dark grayish-brown subsurface layer 2 to 3 inches thick. The subsoil normally is yellowish-brown clay loam that is moderately slow in permeability. This soil is moderately well drained and low in organic-matter content.

This soil is on upland side slopes in the strongly dissected areas of the county. It generally is below the strongly sloping or moderately steep Keswick or Lindley soils and above the soils of the foot slopes and first bottoms. Limestone or sandstone crops out in places.

Included with this soil in mapping, in narrow drainageways, are small areas of Nodaway-Martinsburg silt loams, 2 to 5 percent slopes, and Radford-Ely complex, 2 to 5 percent slopes. Also included are some areas that have a thicker and darker surface layer than this Lindley loam.

Most of this soil is in trees, but a small acreage is cleared and in permanent pasture. Because fertility is low, slopes are steep, and erosion is a severe hazard, this soil is not suited to row crops. It is better suited to permanent pasture or trees. Where permanent pastures are to be improved by seeding legumes, additions of lime are usually needed. (Capability unit VIIe-1; woodland suitability group 3)

Lindley loam, 18 to 25 percent slopes, moderately eroded (LrF2).—This soil has a dark grayish-brown to brown surface layer 2 to 4 inches thick and a yellowish-brown clay loam subsoil. It is moderately well drained, moderately slowly permeable, and low in organic-matter content.

This soil occurs on upland side slopes in the strongly dissected areas of the county. It generally is below the strongly sloping or moderately steep Keswick or Lindley soils and above soils of the foot slopes and first bottoms. Limestone or sandstone crops out in places.

Included with this soil in mapping, in narrow drainageways, are small areas of Nodaway-Martinsburg silt loams, 2 to 5 percent slopes, and Radford-Ely complex, 2 to 5 percent slopes. Also included, in small natural drainageways that extend into the side slopes, are soils that have a darker and thicker surface layer than this Lindley loam. Other inclusions are a few areas of Lindley soils that have a lighter colored and thinner surface layer than this soil. In addition, there are eroded areas that have a yellowish-red or reddish-brown subsoil, some of which is exposed at the surface. A yellowish-brown subsoil is exposed in other eroded areas.

Most of this soil is in permanent pasture. Some areas are in trees, and a small acreage is in crops. This soil is not suited to row crops. It is better suited to permanent pasture or to plantings for wildlife. This soil requires additions of lime to insure good stands of legumes. (Capability unit VIIe-1; woodland suitability group 3)

Lindley loam, 25 to 40 percent slopes (LrG).—This soil has a very dark grayish-brown to dark grayish-brown surface layer 2 to 5 inches thick and normally a yellowish-brown clay loam subsoil. It is moderately well drained, moderately slowly permeable, and low in organic-matter content.

This soil occurs on upland side slopes in strongly dissected areas of the county. It generally is below the strongly sloping or moderately steep Keswick or Lindley soils and above the soils of the foot slopes or first bottoms. Limestone or sandstone crops out in some areas. In places this soil occurs with Sogn soils on the same or adjacent slopes.

Included with this soil in mapping, in narrow drainageways, are small areas of Nodaway-Martinsburg silt loams, 2 to 5 percent slopes, and Radford-Ely complex, 2 to 5 percent slopes. Also included are soils that have a darker colored surface layer than this Lindley soil.

Most of this soil is in trees, but a few areas are in permanent pasture. Because slopes are steep, this soil probably is suited only to pasture, trees, or plantings for wildlife. (Capability unit VIIe-1; woodland suitability group 3)

Lindley soils, 14 to 18 percent slopes, severely eroded (LsE3).—These soils have a brown to yellowish-brown plow layer 4 to 6 inches thick. The plow layer consists of subsoil mixed with a small amount of the remaining surface and subsurface layers. This soil is moderately well drained and moderately slow in permeability. It is very low in organic-matter content.

This soil occurs on upland side slopes adjacent to the strongly dissected areas of the county. It generally is below the strongly sloping Keswick or Clinton soils and above the more strongly sloping areas of Lindley soils or soils of the foot slopes or bottoms. A few areas are above the steep Sogn soils. Slopes normally are convex and relatively short.

Included with these soils in mapping, in narrow drainageways, are small areas of Nodaway-Martinsburg silt loams, 2 to 5 percent slopes, and Radford-Ely complex, 2 to 5 percent slopes. Also included, in the small natural drainageways that extend into the side slopes, are some soils that have a darker surface layer than this Lindley soil. In the heavily gullied areas, some soils are included that have a grayish-brown to brown plow layer 3 to 7 inches thick. Other included areas have a yellowish-red or reddish-brown clay surface layer. In wet years, these soils are seepy and wetter than the other soils in this mapping unit.

This soil is in crops or permanent pasture. Many areas within cultivated fields are left idle. This soil is not suited to row crops. It is low in fertility and very susceptible to erosion. Also, the surface layer is clayey, sticky when wet, and in poor tilth. This soil is better

suited to permanent pasture or trees than to row crops, but establishing a stand of either is often difficult. Additions of lime are required to insure good stands of legumes. (Capability unit VIIe-1; woodland suitability group 2)

Mahaska Series

The Mahaska series consists of somewhat poorly drained soils that developed from loess. The native vegetation was prairie grasses. These soils are on moderately wide upland ridges, in coves of drainageways, and on high stream benches. Slopes range from 0 to 3 percent. In some places Mahaska soils are mapped with Nira soils in a complex.

In a typical profile the surface layer is black and very dark gray silty clay loam about 18 inches thick. The subsoil is silty clay loam that extends to a depth of 61 inches. It is very dark gray, dark grayish brown, and grayish brown in the upper part and olive gray below a depth of about 40 inches. The underlying material is gray to light-gray silty clay loam. Yellowish-brown and grayish-brown mottles occur in the subsoil and substratum.

Mahaska soils have a high available moisture holding capacity and are moderately slowly permeable. The surface layer ranges from very strongly acid to slightly acid, the upper part of the subsoil is very strongly acid to medium acid, and the lower part of the subsoil and the substratum are typically slightly acid to neutral. Mahaska soils are low to medium in available nitrogen and available phosphorus and very low in available potassium.

Typical profile of Mahaska silty clay loam, 965 feet south and 278 feet east of the northwest corner of the NE¼ section 34, T. 77 N., R. 10 W., on a nearly level ridgetop:

Ap—0 to 7 inches, black (10YR 2/1) light silty clay loam; dark gray (10YR 4/1) when dry, black (10YR 2/1) when kneaded; moderate, fine, angular blocky and subangular blocky structure; friable; medium acid; abrupt, smooth boundary.

A1—7 to 13 inches, black (10YR 2/1) medium silty clay loam; moderate, fine, subangular blocky structure that breaks to moderate, fine, granular structure; friable; very strongly acid; clear, smooth boundary.

A3—13 to 18 inches, very dark gray (10YR 3/1) medium silty clay loam; moderate, fine, subangular blocky structure; friable; few, fine, hard concretions of an oxide; very strongly acid; gradual, smooth boundary.

B1—18 to 24 inches, heavy silty clay loam that has dark-gray (10YR 3/1) ped exteriors and olive-brown (2.5Y 4/3) ped interiors; common, fine, distinct mottles of grayish brown (2.5Y 5/2); weak, medium, prismatic structure that breaks to moderate, fine, subangular blocky and very fine subangular blocky structure; friable; many, fine, hard concretions of an oxide; very strongly acid; gradual, smooth boundary.

B2t—24 to 40 inches, dark grayish-brown (10YR 4/2) and grayish-brown (2.5Y 5/2) heavy silty clay loam; few, fine, distinct mottles of yellowish brown (10YR 5/6); moderate, medium, prismatic structure that breaks to moderate, medium, subangular blocky structure; firm; few stains of an oxide on ped exteriors; few, thin, discontinuous, dark-gray (10YR 4/1) clay films; common, fine, hard concretions of an oxide; strongly acid; gradual, smooth boundary.

B3tg—40 to 61 inches, medium silty clay loam that has olive-gray (5Y 5/2) ped exteriors and light olive-gray (5Y 6/2) ped interiors; common, medium and fine, prominent mottles of yellowish brown (10YR 5/6); weak, medium, prismatic structure; firm; few vertical clay flows about 2 to 3 millimeters wide on prism faces that are black (10YR 2/1) in color; few prism faces are dark gray (10YR 4/1) and have more prominent thin clay flows; numerous very fine clay flows in very fine pores; colors typical of a deoxidized weathering zone; medium acid; gradual, smooth boundary.

Cg—61 to 73 inches, gray to light-gray (5Y 6/1) light silty clay loam; common, fine, distinct mottles of yellowish brown (10YR 5/6); massive (structureless) but has a few vertical cleavage faces; firm; a few medium black (10YR 2/1) clay accumulations in vertical pores; few, fine, soft concretions of an oxide; colors typical of a deoxidized weathering zone; neutral.

The A1 or Ap horizon ranges from black or very dark brown to very dark gray. The B horizon generally ranges from dark grayish brown in the upper part to grayish brown or olive gray in the lower part, and it has yellowish-brown and strong-brown mottles. The maximum clay content of the B horizon ranges from 36 to 42 percent. These soils are leached to a depth of 4 feet or more and are very strongly acid in the most acid part of the solum.

Mahaska soils have a thicker and darker colored surface layer than Givin soils and lack the light-colored subsurface layer. They have a browner color in the upper part of the subsoil than Taintor soils and are deeper to the layer of maximum clay content. Mahaska soils are grayer in the upper part of the subsoil than Otley soils and have a more distinctly mottled subsoil.

Mahaska silty clay loam, 1 to 3 percent slopes (MaA).—This soil has a black to very dark brown surface layer 11 to 21 inches thick. The subsoil is a mottled very dark gray to light olive-brown silty clay loam that is moderately slow in permeability.

This soil is adjacent to the nearly level Taintor soils and above the more strongly sloping Otley soils. It also occurs on moderately wide ridgetops in prairie areas, where it is associated with more strongly sloping Otley soils and, in some places, with Ladoga soils.

Included with this soil in mapping are areas of level and slightly depressional, poorly drained soils that are too small to delineate.

Nearly all of this soil is used for cultivated crops. Crops grow well. Many areas are large enough to farm separately, but normally it is farmed with the nearly level Taintor and gently sloping Otley soils. With careful management, row crops can be grown almost continuously.

This soil is high in organic-matter content. Tilth is generally good, and there is little or no erosion hazard.

Plowing under all crop residue helps to maintain tilth and fertility. Additions of lime are beneficial. Most areas of this soil need drainage improvement and should not be worked when they are wet. Tile drains function well in this soil. (Capability unit I-1; woodland suitability group 4)

Mahaska silty clay loam, benches, 1 to 3 percent slopes (MhA).—This soil is similar to Mahaska silty clay loam, 1 to 3 percent slopes, except that it is on nearly level loess-covered benches underlain by alluvium at a depth of 10 to 15 feet. It is adjacent to the nearly level Taintor soils and above the more strongly sloping Otley soils on the same benches. The largest and most extensive areas of this soil are south and east of Sigourney near the North Skunk River. Other areas are along the valleys of the Skunk Rivers and other major streams.

Included with this soil in mapping are small areas of level and slightly depressional, poorly drained soils. They are shown on the soil map with a spot symbol for wet areas.

Nearly all of this soil is used for cultivated crops. Although some areas are large enough to farm separately and crops grow well, this soil normally is farmed with the nearly level Taintor soils and other soils on the same bench. With careful management, row crops can be grown almost continuously.

Because this soil is fertile, has high content of organic matter, and there is little or no erosion hazard, only ordinary practices of management generally are needed for good growth of crops. Additions of lime are beneficial. Some areas need drainage improvement and should not be worked when they are wet. Tile drains function well in this soil. (Capability unit I–1; woodland suitability group 4)

Martinsburg Series

The soils of the Martinsburg series are well drained to moderately well drained. They developed from local silty alluvium on foot slopes and alluvial fans under a native vegetation of trees. Slopes range from 2 to 9 percent. In some places Martinsburg soils are mapped in a complex with Nodaway soils in narrow upland drainageways.

In a typical profile the surface layer is dark-brown and dark grayish-brown silt loam about 6 inches thick. The subsurface layer, which extends to a depth of about 20 inches, is brown and dark-brown silt loam. These layers are distinctly light colored when dry. The subsoil is brown, dark yellowish-brown, and yellowish-brown, friable silty clay loam that extends to a depth of 70 inches. A few grayish mottles are present in the lower part of the subsoil.

Martinsburg soils are moderately permeable and have a high available moisture holding capacity. The surface layer normally is medium acid to slightly acid. The subsurface layer and subsoil are medium acid and strongly acid, and the substratum is medium acid to slightly acid in most places. These soils are low in available nitrogen, medium to high in available phosphorus, and very low in available potassium.

Typical profile of Martinsburg silt loam, 1,300 feet east and 2,550 feet north of the southwest corner of section 8, T. 75 N., R. 13 W., on a 3 percent slope that faces north:

Ap—0 to 6 inches, dark-brown (10YR 3/3) and dark grayish-brown (10YR 4/2) silt loam; pale brown (10YR 6/3) when dry, dark grayish brown (10YR 4/2) when kneaded; common, fine, faint mottles of yellowish brown (10YR 5/4); weak, medium, platy breaking to weak, fine, granular structure; friable; discontinuous, distinct, grainy coats that are light gray (10YR 7/2) when dry; medium acid; abrupt, smooth boundary.

A21—6 to 13 inches, silt loam that has brown (10YR 4/3) ped exteriors and yellowish-brown (10YR 5/4) ped interiors; few, fine, faint mottles of light yellowish brown (10YR 6/4); weak, medium, platy and weak, fine, subangular blocky structure; friable; continuous, distinct, grainy coats that are white (10YR 8/1) when dry cover most peds; a very few, fine, soft concretions of a black oxide; medium acid; gradual, smooth boundary.

A22—13 to 20 inches, heavy silt loam that has dark-brown (10YR 3/3) ped exteriors and brown (10YR 4/3) ped interiors; few, fine, faint mottles of brown (10YR 5/3); weak, fine, subangular blocky structure; friable; on most peds are continuous, distinct, grainy coats that are white (10YR 8/1) when dry; very few, fine, soft concretions of a black oxide; medium acid; gradual, smooth boundary.

B1t—20 to 27 inches, light silty clay loam that has brown (10YR 4/3) ped exteriors and dark yellowish-brown (10YR 4/4) ped interiors; weak, medium, prismatic structure that breaks to weak, fine, subangular blocky structure; friable; few, thin, discontinuous, dark-brown (10YR 3/3) clay films; on most peds are continuous, distinct, grainy coats that are white (10YR 8/1) when dry; very few, fine, soft concretions of a black oxide; strongly acid; gradual, smooth boundary.

B2t—27 to 41 inches, light silty clay loam that has brown (10YR 4/3) ped exteriors and brown (10YR 4/3) to yellowish-brown (10YR 5/4) ped interiors; few, fine, faint mottles of pale brown (10YR 6/3) and yellowish brown (10YR 5/4); weak, medium, prismatic structure that breaks to weak, fine, subangular blocky structure; friable; on most peds are continuous, distinct, grainy coats that are white (10YR 8/1) when dry; few, thin, discontinuous, dark-brown (10YR 3/3) clay films; very few, fine, soft concretions of a black oxide; strongly acid; gradual, smooth boundary.

B31t—41 to 57 inches, medium silty clay loam that has dark yellowish-brown (10YR 4/4) ped exteriors and yellowish-brown (10YR 5/4) ped interiors; few, fine, faint mottles of strong brown (7.5YR 5/8) and light brownish gray (2.5Y 6/2); weak, medium, prismatic structure that breaks to weak, fine, subangular blocky structure in the upper part of horizon; friable; few, thin, discontinuous, dark-brown (10YR 3/3) clay films; on most peds and along prisms are continuous, distinct, grainy coats that are white (10YR 8/1) when dry, though some patches are thick; very few, fine, soft concretions of black and brown oxides; strongly acid; gradual, smooth boundary.

B32t—57 to 70 inches, light silty clay loam that has dark yellowish-brown (10YR 4/4) ped exteriors and dark yellowish-brown (10YR 4/4) and some yellowish-brown (10YR 5/6) ped interiors; few, fine, faint mottles of brown (10YR 5/3) and light brownish gray (2.5Y 6/2); weak, coarse, prismatic structure; friable; common, thin, discontinuous, dark-brown (10YR 3/3) clay films; discontinuous, distinct, grainy coats that are white (10YR 8/1) when dry on approximately half of prism surfaces; common, fine, soft concretions of a black oxide and few, fine, soft concretions of a brown oxide; strongly acid; gradual, smooth boundary.

In undisturbed areas, the A1 horizon ranges from 4 to 8 inches in thickness and from very dark brown to dark grayish brown in color. The A2 horizon ranges from 10 to 16 inches in thickness and from dark grayish brown to brown in color. Depth to the B horizon ranges from 18 to 24 inches. The B horizon ranges from silt loam to silty clay loam in texture, from dark brown to brown to yellowish brown in color and from weak to moderate in structure. Thickness of the B horizon is more than 40 inches in most places. Grayish mottles may be present in the lower part of the solum. The solum is medium acid to strongly acid in the most acid part. The underlying material is massive and consists of yellowish-brown, friable silty clay loam and silt loam.

Martinsburg soils have a lighter colored, thinner surface layer than Judson soils and a brownish subsurface layer that Judson soils lack. Unlike Nodaway and Radford soils, Martinsburg soils have a distinct brownish subsoil. They lack the dark buried soil that occurs in the Radford soils at a depth of about 30 inches.

Martinsburg silt loam, 2 to 5 percent slopes (MrB).—This soil has a very dark gray to very dark grayish-brown surface layer 12 to 18 inches thick and a moderately permeable, brown to yellowish-brown subsoil.

This soil generally occurs as narrow bands at the base of slopes occupied by Clinton soils or Lamont-Clinton-Chelsea complex, 5 to 9 percent slopes. It is above the Vesser, Radford, Amana, and Nodaway soils of the first bottoms. In some areas this soil occurs with Nodaway-Martinsburg silt loams, 2 to 5 percent slopes. Included with this soil in mapping are areas of a soil that has a loam surface layer.

This soil is nearly all cultivated. It is well suited to corn, soybeans, small grains, forage grasses, and legumes. Where it is tilled on the contour and protected from runoff by diversion terraces, row crops can be grown frequently.

This soil generally is farmed with the soils of the bottoms rather than with those of the more sloping uplands. The diversion terraces are constructed at the base of the upland slopes. Although the organic-matter content is low, tilth is generally good and can be improved by growing more meadow crops. This soil is acid unless recently limed, and additions of lime are needed for good crop growth. (Capability unit IIe–2; woodland suitability group 1)

Martinsburg silt loam, 5 to 9 percent slopes (MrC).—This soil is similar to Martinsburg silt loam, 2 to 5 percent slopes, except that it is more sloping and has a slightly thinner surface layer. It generally occurs as narrow bands at the base of slopes occupied by separate areas of Clinton soils or by Lamont-Clinton-Chelsea complex, 5 to 9 percent slopes. It is above gently sloping Martinsburg soils but on the same foot slopes. It also is above Vesser, Radford, Amana, and Nodaway soils of the first bottoms. In some areas this soil occurs with Nodaway-Martinsburg silt loams, 2 to 5 percent slopes. Included in mapping are soils that have a loam surface layer.

Nearly all of this soil is cultivated. It frequently can be used for row crops if tillage is on the contour and diversion terraces are used to carry away water from adjacent hillsides. This soil is well suited to corn, soybeans, small grains, forage grasses, and legumes.

Crops grow moderately well on this soil. Organic-matter content is low, but tilth normally is good. If tilth becomes poor, it can be improved by growing more meadow crops. Additions of lime are needed for good crop growth. (Capability unit IIIe-1; woodland suitability group 1)

Nira Series

The Nira series consists of moderately well drained soils that developed from brownish and grayish loess under a native vegetation of prairie grasses. These soils are on short, convex, upland side slopes and on slopes bordering coves of drainageways adjacent to the Otley and Mahaska soils. Slopes range from 1 to 3 percent. In Keokuk County these soils occur only in complexes with Mahaska and Givin soils.

In a typical profile the surface layer is very dark gray and black silty clay loam about 10 inches thick. The subsoil extends to a depth of 42 inches. Color is dominantly brownish to a depth of 34 inches and is gray to olive gray below that depth. Mottling begins at a depth of 17 inches and is mainly grayish brown, yellowish red, and yellowish brown.

Nira soils have a high available moisture holding capacity. They are moderately slowly permeable. The surface layer is medium acid to slightly acid, the subsoil is medium acid to strongly acid in the most acid part, and the substratum is typically slightly acid. Nira soils are typically low to medium in available nitrogen and very low in available phosphorus and available potassium.

Typical profile of Nira silty clay loam, 792 feet west and 752 feet south of road center near the northeast corner of the NW¼ section 34, T. 77 N., R. 10 W., about 2 miles south of Kinross.

Ap—0 to 7 inches, very dark gray (10YR 3/1) medium silty clay loam; weak, medium, subangular blocky structure; friable; slightly acid; abrupt, smooth boundary.

A3—7 to 10 inches, black to very dark gray (10YR 2/1 to 3/1) heavy silty clay loam; weak, fine, subangular blocky structure; friable; few brown (10YR 4/3) peds; medium acid; clear, smooth boundary.

B21t—10 to 17 inches, heavy silty clay loam that has brown (10YR 4/3) and 20 percent very dark grayish-brown (10YR 3/2) ped exteriors, brown (10YR 4/3) and 10 percent grayish-brown (2.5YR 5/2) ped interiors; moderate, fine, subangular blocky structure; firm; few, thin, discontinuous clay coats; few, fine, hard, dark-brown to black nodules of iron and manganese; medium acid; gradual, smooth boundary.

B22t—17 to 22 inches, medium to heavy silty clay loam; same colors as in the B21t horizon except that 20 percent is mottled with grayish brown (2.5Y 5/2); weak, medium, prismatic structure that breaks to moderate, medium, subangular blocky structure; firm; strongly acid; clear, smooth boundary.

B31t—22 to 34 inches, light to medium silty clay loam that has mottled yellowish-brown (10YR 5/4) and grayish-brown (2.5Y 5/2) ped exteriors and gray (5Y 5/1) ped interiors; common, fine, strong-brown (7.5YR 5/6) mottles or soft nodules and very few, fine, yellowish-red (5YR 4/6) mottles or soft nodules; weak, coarse, prismatic structure that breaks to weak, medium, subangular blocky structure; firm; interior colors typical of a deoxidized and leached weathering zone; medium to strongly acid; gradual, smooth boundary.

B32t—34 to 42 inches, gray to olive-gray (5Y 5/1 to 5/2) light silty clay loam; many, medium, yellowish-brown (10YR 5/6) mottles; weak, coarse prismatic structure; firm; common, fine, soft, dark-brown to black nodules of iron and manganese; few clay coats in pores; colors typical of a deoxidized and leached weathering zone; medium acid; diffuse, smooth boundary.

Cg—42 to 60 inches, characteristics same as in B32t horizon except that Cg horizon is massive.

The A horizon ranges from silt loam to silty clay loam in texture and from black to very dark gray in color. The depth to predominant gray matrix colors and depth to mottling range from 20 to 30 inches. The maximum content of clay is 38 percent where horizons are thin. In some places gumbotil, or dense silty clay, occurs below a depth of 60 inches. The solum is strongly acid in the most acid part.

Nira soils have browner colors in the upper part of the subsoil than have the Mahaska soils and are shallower to the maximum clay layer. The subsoil of Nira soils is lower in clay content than that of Mahaska soils. Nira soils have a darker colored, thicker surface layer than Givin soils and lack the grayish subsurface layer that is present in those soils.

Nira-Givin complex, 1 to 3 percent slopes (NgB).—This complex consists of Givin soils similar to Givin silt loam, 1 to 3 percent slopes, and of Nira soils that generally have a black to very dark gray silty clay loam surface layer and a grayish-brown to olive-gray to light olive-gray subsoil at a depth of about 20 inches. The subsoil

of Nira soils typically has a lower clay content than that of the Givin.

The soils of this complex are in the uplands at the heads of drainageways below other Givin soils and above Ladoga or Clarinda soils. The depth to the grayish subsoil normally is less near the drainageway and downslope. Included in this complex in mapping are some areas of moderately well drained, steeper soils.

The soils of this complex are moderately well suited to corn, soybeans, small grain, forage grasses, and legumes. Where these soils are terraced or contoured, row crops can be grown frequently.

Because the erosion hazard is slight, terraces or contour tillage is needed to control loss of soil. Slightly wet areas are improved by installation of tile. Some areas of Nira soils are seasonally wet and seepy. The soils in this complex need additions of lime. (Capability unit IIe–1; woodland suitability group 4)

Nira-Mahaska silty clay loams, 1 to 3 percent slopes (NmB).—This complex consists of Nira and Mahaska soils so intermingled that they cannot be mapped separately. The Nira soils are generally on the lower slopes and have a black to very dark brown or very dark gray silty clay loam surface layer about 10 inches thick. A grayish-brown to olive-gray or light-gray subsoil is present at a depth of 18 to 30 inches. In more than half the areas the gray zone is at a depth of 30 inches or less. Nira soils are seasonally wet and seepy. The Mahaska soils have a surface layer of black to very dark brown silty clay loam 11 to 21 inches thick. The subsoil is moderately slowly permeable, mottled very dark gray to light olive-brown silty clay loam.

These soils are at the heads of drainageways and below the adjacent nearly level Mahaska soils on the divide. They are above the adjacent Otley soils, and some areas are adjacent to moderately sloping Clarinda soils.

Included with these soils in mapping, generally in convex areas between small water courses, are steeper moderately well drained soils that have a browner surface layer.

These Nira and Mahaska soils are well suited to corn, soybeans, small grains, forage grasses, and legumes. Where terraced, they can be intensively used for row crops.

The Nira soils generally are seasonally wet or seepy, and tile drains are installed in some drainageways that dissect these areas. The Nira and Mahaska soils are medium to high in fertility. Since they are normally acid, they need additions of lime. (Capability unit IIe–1; woodland suitability group 4)

Nodaway Series

The Nodaway series consists of stratified, moderately well drained soils that developed from silty alluvium. When dry, these soils typically have light-colored surfaces. Recent vegetation consisting of trees and prairie grasses has not influenced soil development. These soils are nearly level to undulating on low first bottoms and have 2 to 5 percent slopes in narrow upland drainageways. Most areas are adjacent to present stream channels. In some places these soils are mapped in a complex with Alluvial land near river channels, and in other places they are mapped with Martinsburg soils in upland drainageways.

In a typical profile the surface layer is very dark grayish-brown and dark-gray silt loam 3 inches thick. The underlying material is stratified dark grayish-brown and brown silt loam to a depth of 12 inches and highly stratified very dark grayish-brown, brown, and dark grayish-brown silt loam to a depth of 55 inches.

Nodaway soils are moderately permeable and have a high available moisture holding capacity. They typically are neutral to mildly alkaline, but are not calcareous to a depth of 40 inches or more. Amounts of available nitrogen, phosphorus, and potassium are variable.

Typical profile of Nodaway silt loam, 700 feet west and 2,000 feet south of the northeast corner section 4, T. 74 N., R. 12 W., on the nearly level flood plain of the South Skunk River:

A—0 to 3 inches, very dark grayish-brown (10YR 3/2) and dark-gray (10YR 4/1) silt loam, brown (10YR 5/3) when dry, very dark grayish brown (10YR 3/2) to dark grayish brown (10YR 4/2) when kneaded; weak, thin platy structure that crushes readily to weak, very fine, granular structure; very friable; common almost continuous silt coats on horizontal faces of plates that are white (10YR 8/1) when dry and dark gray (10YR 4/1) and dark grayish brown (10YR 4/2) when moist; some plates are very dark gray (10YR 3/1) where silt coats are absent; common brown (10YR 5/3) bedded silt in which strata commonly are 3.5 millimeters thick; mildly alkaline; abrupt, smooth boundary.

C1—3 to 12 inches, stratified dark grayish-brown (10YR 4/2) and brown (10YR 5/3) silt loam, grayish brown (10YR 5/2) and light gray (10YR 7/2) when dry; weak, thin to thick, platy structure that breaks to weak, fine, granular structure; friable; dark grayish brown (10YR 3/2) on some horizontal plates and light brownish gray (10YR 6/2) on others; few very dark gray (10YR 3/1) worm casts; mildly alkaline; clear, smooth boundary.

C2—12 to 55 inches, highly stratified very dark grayish-brown (10YR 3/2) to brown (10YR 4/3) and dark grayish-brown (10YR 4/2) silt loam, grayish brown (10YR 5/2) and pale brown (10YR 6/3) when dry; alternate strata 2 to 3 millimeters thick; few, fine, distinct mottles of yellowish brown (10YR 5/6); weak, thin to thick, platy structure that breaks to very weak, fine, granular structure; friable; very few thin bands of pale-brown (10YR 6/3) very fine sand; mildly alkaline.

The solum ranges from 10 to 20 percent in content of sand. Most of the sand is very fine, but coarser and finer sand occurs in thin strata. A dark-colored buried soil occurs at a depth of more than 36 inches in some places. The profile ranges from slightly acid or neutral to mildly alkaline but is noncalcareous.

The dark buried soil in Nodaway soils is not at a depth of only about 24 inches as it is in the Radford soils. Nodaway soils are highly stratified and do not have the distinct surface layer and subsoil that occur in Amana soils. Also, Nodaway soils are less acid than Amana soils and lack the grainy coats that make the subsoil distinctly light colored when dry. Nodaway soils are less variable in texture than Alluvial land.

Nodaway silt loam (No).—This soil generally has a very dark grayish-brown to brown plow layer about 7 inches thick. It is friable and shows little development in the profile. In some areas a dark buried soil may be present at depths below 36 inches. The subsoil is moderately permeable. The underlying material is stratified silt loam alluvium.

This soil occurs on the low bottoms of the major streams and their main tributaries in close association

with Amana and Chequest soils and Alluvial land. Slopes range from 0 to 2 percent. Most areas are highly stratified, but a few areas are included that have little or no stratification.

This soil is used intensively for row crops, except where it is in trees or pasture. It is well suited to corn and soybeans.

In spring this soil is subject to flooding that often interferes with plowing and planting. Where practical, dikes and levees are needed. Areas that are in pasture or trees are flooded more frequently than cultivated areas. Tilth is good, and crops grow well on this soil. It does not require liming. (Capability unit I–2; woodland suitability group 9)

Nodaway silt loam, channeled (Ns).—This undulating soil has more lenses of coarse silt and very fine sand and is more stratified than Nodaway silt loam. It occurs on first bottoms next to stream channels and is dissected by many meandering streams and oxbows. The channels cannot be crossed with farm machinery and are filled with water and clayey sediments in many places. Slope ranges from 0 to 2 percent. This soil is closely associated with Alluvial land.

Because the hazard of flooding is severe, this soil is not suited to cultivated crops. Most of it is in trees, but some is in pasture, both of low quality. This soil is suited to trees, pasture, and plantings for wildlife. Lime is not needed. (Capability unit Vw–1; woodland suitability group 9)

Nodaway-Martinsburg silt loams, 2 to 5 percent slopes (NwB).—This complex consists of Nodaway silt loam and Martinsburg silt loam that are so closely intermingled that they are mapped as a complex. The Nodaway soil lies adjacent to streams along the narrow upland drainageways and in many places is covered with 4 to 6 inches of recently deposited sandy sediments. In many places, the Nodaway soil is cut by channels and gullies that cannot be crossed with farm machinery. The Martinsburg soils are in fairly uniform bands at the base of slopes. This complex is extensive in Keokuk County. The largest acreages occur in the rolling to steep areas where the adjacent soils developed under a native vegetation of timber.

Included with these soils in mapping are darker colored, somewhat poorly drained to moderately well drained soils at the base of slopes in the wider drainageways. Also included, where the adjacent slopes are rolling to very steep, are areas of moderately well drained soils that have a loam surface layer.

These soils are well suited to all crops commonly grown in the county. Small patches in cultivated fields, however, are planted to the same crops as the surrounding soils. Because of gullies and adjoining land use, many areas are left in pasture. If gullying is prevented and these soils are protected from runoff, they can be used for row crops most of the time.

Diversion terraces can be built to control runoff. Tile lines are often needed to control seepage water. The Nodaway soils normally are neutral, but areas of Martinsburg silt loam are acid unless recently limed. (Capability unit IIw–3; woodland suitability group 9)

Olmitz Series

The Olmitz series consists of moderately well drained soils that developed from local loamy alluvium under a native vegetation of prairie grasses. These soils are on nearly straight to slightly concave alluvial fans and foot slopes. Slopes range from 3 to 7 percent. Olmitz soils normally are downslope from Shelby or Gara soils.

In a typical profile the surface layer is about 29 inches thick. It is very dark gray and very dark grayish-brown loam in the upper 13 inches and light clay loam below. The subsoil, which extends to a depth of 60 inches, is friable clay loam. It is dark brown and brown in the upper part and yellowish brown and brown below a depth of about 46 inches.

Olmitz soils are moderately permeable and have a high available moisture holding capacity. The surface layer ranges from neutral to medium acid, and the subsoil typically is medium acid. These soils are medium to low in available nitrogen and very low in available phosphorus and available potassium.

Typical profile of Olmitz loam, 640 feet north and 250 feet west of the southeast corner section 27, T. 75 N., R. 10 W., on a convex foot slope of 8 percent that faces south:

Ap—0 to 6 inches, very dark gray (10YR 3/1) and very dark grayish-brown (10YR 3/2) loam, very dark grayish brown (10YR 3/2) when kneaded; cloddy to weak, fine, granular structure; friable; neutral; abrupt, smooth boundary.

A11—6 to 13 inches, very dark gray (10YR 3/1) and very dark grayish-brown (10YR 3/2) loam, very dark brown (10YR 2/2) when kneaded; weak, fine, subangular blocky structure that breaks to moderate, fine, granular structure; friable; slightly acid; clear, smooth boundary.

A12—13 to 21 inches, very dark gray (10YR 3/1) and very dark grayish-brown (10YR 3/2) light clay loam; weak, medium, prismatic structure that breaks to moderate, fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

A3—21 to 29 inches, light clay loam that has very dark grayish-brown (10YR 3/2) ped exteriors and dark-brown (10YR 3/3) ped interiors; dark brown to brown (10YR 3/3) when kneaded; weak, medium, prismatic structure that breaks to moderate, fine and medium, subangular blocky structure; friable; medium acid; gradual, smooth boundary.

B1t—29 to 40 inches, light clay loam that has dark-brown (10YR 3/3) ped exteriors and brown (10YR 4/3) ped interiors; few ped coats of light gray (10YR 7/2) when dry; weak, medium, prismatic structure that breaks to weak, medium, subangular blocky structure; friable; thin, discontinuous, dark-brown (10YR 3/3) clay films on peds; medium acid; gradual, smooth boundary.

B2t—40 to 46 inches, light clay loam that has brown (10YR 4/3) ped exteriors and dark yellowish-brown (10YR 4/4) ped interiors; dark yellowish brown (10YR 4/4) when kneaded; few fine sand ped coats of light gray (10YR 7/2) when dry; weak, medium, prismatic structure that breaks to weak, medium, subangular blocky structure; thin, discontinuous, dark-brown (10YR 3/3) clay films; friable; medium acid; gradual, smooth boundary.

B3t—46 to 60 inches, light clay loam that has yellowish brown (10YR 5/6) and brown (10YR 5/3) on vertical ped faces; few prominent coatings of fine sand on vertical cleavage faces; coatings of light gray (10YR 7/2) when dry; weak, medium, prismatic structure; friable; few thin clay fills in soil pores; few discontinuous clay films on prism faces; medium acid.

The A horizon ranges from black and very dark gray to very dark grayish brown in color and from 15 to 30 inches in thickness. The B horizon ranges from very dark grayish brown and dark brown to yellowish brown in color and from light to medium clay loam in texture. Clay films are visible but are thin and patchy. In some places grayish mottles occur in the lower part of the B horizon. Depth to gracial till varies, but typically it is 48 inches or more. These soils are medium acid in the most acid part.

The Olmitz soils are better drained than Ely soils and have browner chroma in the subsoil, are less intensely mottled, and are higher in content of sand. They have a higher sand content throughout than Judson soils. They have a thicker, darker surface layer than Martinsburg soils and more sand in the subsoil. Olmitz soils lack the grayish subsurface layer, distinctly light colored when dry, that is present in Martinsburg soils. Also, the subsoil of Olmitz soils does not have the grainy coats that occur in the subsoil of Martinsburg soils.

Olmitz loam, 3 to 7 percent slopes (OlC).—This soil has a black to very dark gray or very dark grayish-brown surface layer, depending on the amount and kind of sediments that have been recently deposited. In most areas these sediments are 15 to 30 inches thick. The subsoil is a moderately permeable, very dark gray to yellowish-brown clay loam.

This soil occurs at the base of slopes of till-derived Shelby, Gara, Adair, or Keswick soils. A few areas are on alluvial fans at the mouths of upland waterways.

Included with this soil in mapping are some areas of a soil that has a clay loam surface layer.

Most of this Olmitz soil is used intensively for row crops. In most places this soil is cultivated with the soils of the adjoining bottoms. It is well suited to corn, soybeans, small grains, forage grasses, and legumes. Tilth is usually good, and crops grow well on this soil.

Because of the slight erosion hazard, this soil should be tilled on the contour. A terrace constructed upslope diverts runoff from the adjoining slopes and helps prevent formation of small gullies. This soil is medium to high in organic-matter content, but additions of lime are beneficial. (Capability unit IIe-2; woodland suitability group 2)

Otley Series

The Otley series consists of moderately well drained soils that developed from loess under a native vegetation of prairie grasses. They are on convex slopes, upland ridges, and high benches along streams. Slopes range from 2 to 14 percent. Otley soils are downslope from Mahaska and Taintor soils on stable upland divides and upslope from the glacial till-derived Adair and Shelby soils.

In a typical profile the surface layer is black to very dark brown light to medium silty clay loam about 17 inches thick. The subsoil, which extends to a depth of 61 inches, is firm, heavy to light silty clay loam. It is very dark grayish brown, dark brown, and brown to a depth of 40 inches and grayish brown, light olive gray, and brownish yellow below. Below 40 inches the subsoil is mottled with yellowish brown and dark brown. The underlying material is yellowish-brown to light olive-brown silt loam mottled with dark brown.

Otley soils are moderately slowly permeable and have a high available moisture holding capacity. The surface layer is acid unless recently limed. The subsoil is mostly medium acid to strongly acid, and the substratum is slightly acid to neutral. Otley soils are low in available nitrogen and available phosphorus and very low in available potassium.

Typical profile of Otley silty clay loam, 154 feet east and 481 feet south of the northwest corner of the SW1/4-NE1/4, section 34, T. 77 N., R. 10 W., near the crest of a ridgetop on a slope of 1.5 percent that faces south:

Ap—0 to 7 inches, black (10YR 2/1) light silty clay loam, very dark brown (10YR 2/2) when kneaded; moderate, medium, subangular blocky structure that breaks to weak, fine, granular structure; friable; medium acid; abrupt, smooth boundary.

A1—7 to 12 inches, black (10YR 2/1) to very dark brown (10YR 2/2) light silty clay loam, very dark brown (10YR 2/2) when kneaded; weak, fine, subangular blocky structure; friable; strongly acid; gradual, smooth boundary.

A3—12 to 17 inches, mixed, very dark brown (10YR 2/2) medium silty clay loam; weak, very fine, subangular blocky structure that breaks to moderate, fine, granular structure; friable; strongly acid; clear, smooth boundary.

B21t—17 to 26 inches, mixed dark-brown (10YR 4/3) and very dark grayish-brown (10YR 3/2) heavy silty clay loam; very few, very fine, faint mottles of dark grayish brown (2.5Y 4/2); moderate, very fine, subangular blocky structure; firm; few, fine, soft concretions of an oxide; very strongly acid; gradual, smooth boundary.

B22t—26 to 32 inches, heavy silty clay loam that has dark-brown (10YR 4/3) ped exteriors and yellowish-brown (10YR 5/4) ped interiors; few, fine, distinct mottles of dark reddish brown (5YR 3/3) and very few, fine, faint mottles of dark grayish brown (2.5Y 4/2); moderate, very fine and fine, subangular blocky structure; firm; thin continuous clay films on all peds; few, fine, soft concretions of an oxide; strongly acid; gradual, smooth boundary.

B23t—32 to 40 inches, medium silty clay loam that has brown (10YR 5/3) ped exteriors and grayish-brown (2.5Y 5/2) ped interiors; few, fine, prominent mottles of reddish brown (5YR 3/3); weak, medium, prismatic structure that breaks to moderate, medium and fine, subangular blocky structure; firm; some dark grayish-brown (10YR 4/2) stains on peds in places; few, thin, discontinuous clay films on peds; few, fine, soft concretions of an oxide; strongly acid; gradual, smooth boundary.

B31t—40 to 53 inches, grayish-brown (2.5Y 5/2) light silty clay loam; common, medium, distinct mottles of yellowish brown (10YR 5/4); weak, coarse, prismatic structure that breaks to weak, coarse and medium, angular blocky structure; firm; some faint coatings of silt grains on prism faces; distinct (1 inch to 3 inches thick) horizontal band of strong brown (7.5YR 5/6) extending to depth of 56 inches; color typical of a deoxidized weathering zone; common, coarse, soft concretions of an oxide; medium acid; diffuse, wavy boundary.

B32t—53 to 61 inches, light olive-gray (5Y 6/2) and brownish-yellow (10YR 6/6) light silty clay loam; common, medium, distinct mottles of dark brown; weak, coarse, prismatic structure that breaks to weak, coarse, angular blocky; firm; some pores or root channels filled with very dark gray (10YR 3/1) clay; thin, prominent, dark-brown (10YR 3/3) clay films on vertical cleavage faces in places; clay films decrease in color, intensity, and thickness with depth; colors typical of a deoxidized weathering zone; few, fine, hard concretions of an oxide; slightly acid; diffuse, smooth boundary.

C—61 to 73 inches, yellowish-brown (10YR 5/4) to light olive-brown (2.5Y 5/4) heavy silt loam; common, medium, distinct mottles of dark brown (10YR 3/3); massive with vertical cleavage; firm; distinct strong-brown

(7.5YR 5/6) colors in irregular horizontal bands from 1 to 2 inches wide; light olive-gray (5Y 6/2) colors intermixed with bands; thin clay films on cleavage faces extend from B32t horizon; some fine root holes or vertical pores filled with very dark gray (10YR 3/1) clay; few, very fine, hard concretions of an oxide; colors typical of an oxidized weathering zone; neutral; diffuse, wavy boundary.

The A horizon ranges from black to very dark brown but is very dark grayish brown in some eroded areas. In the B horizon colors are centered on dark brown to yellowish brown. Grayish-brown to olive-gray mottles occur below a depth of about 30 inches in some places. Above 30 inches the grayish mottles are very few and faint. In some places below a depth of 36 inches are olive-gray colors that are those of relict deoxidized loess. The C horizon generally is light silty clay loam, but it grades to silt loam at a depth of 70 to 80 inches. Otley soils are leached of carbonates to depths of 6 or 7 feet or more. They range from very strongly acid to medium acid in the most acid part.

Otley soils have a thicker, darker surface layer than Ladoga soils and lack the grayish subsurface layer and grainy coatings in the subsoil. They have a subsoil that is browner and less mottled than that of the somewhat poorly drained Mahaska soils. Otley soils do not have the gray and olive-gray colors that are present in the subsoil of the Nira soils at a depth of about 24 inches.

Otley silty clay loam, 2 to 5 percent slopes (OtB).—This soil has a very dark brown to black surface layer 10 to 15 inches thick. The moderately slowly permeable subsoil is generally dark-brown to yellowish-brown silty clay loam.

This soil is on ridgetops, and in many places it occurs in continuous bands that extend downslope from Mahaska or other soils on broad upland flats. It is generally above Colo-Ely silty clay loams, 2 to 5 percent slopes, and a few areas are above moderately sloping Clarinda and Ladoga soils. This soil is one of the most extensive in the county, and individual areas are large in many places.

Included with this soil in mapping are dark-colored soils in small natural drainageways. Also included, at the heads of drainageways, are small areas of wet and seepy soils and soils that have a thicker and darker surface layer than this Otley soil.

This soil is well suited to corn, soybeans, small grains, forage grasses, and legumes. Although erosion is a hazard in row cropped areas, row crops can be grown where this soil is tilled on the contour.

This soil is high in organic-matter content and is generally in good tilth. It needs additions of lime. (Capability unit IIe–1; woodland suitability group 1)

Otley silty clay loam, 5 to 9 percent slopes (OtC).—This soil has a very dark brown surface layer 7 to 12 inches thick and a generally dark-brown to yellowish-brown silty clay loam subsoil that is moderately slowly permeable.

It is below gently sloping Otley soils and above more strongly sloping Otley soils, and moderately sloping to strongly sloping Clarinda, Lamoni, or Adair soils, or Colo-Ely silty clay loams, 2 to 5 percent slopes.

Included with this soil in mapping are areas that have a thinner, browner surface layer. Also included are some dark-colored soils in small drainageways. Where this soil occurs at the heads of drainageways, soils are included that are similar to the Nira soils and are grayish in the lower part of the subsoil.

Most of this Otley soil is used for row crops, but a few areas are in permanent pasture. Where it is terraced or tilled on the contour, this soil is suited to row crops.

This soil is generally farmed with better soils on gentle slopes. Since the hazard of erosion is moderate, terraces or contour tillage is needed to help prevent soil loss. This soil is high in organic-matter content and is generally in good tilth. Additions of lime are beneficial. (Capability unit IIIe-1; woodland suitability group 1)

Otley silty clay loam, 5 to 9 percent slopes, moderately eroded (OtC2).—This soil has a very dark gray to very dark grayish-brown plow layer 5 to 7 inches thick. The plow layer consists of the remaining surface layer mixed with a small amount of subsoil. The subsoil is generally dark-brown to yellowish-brown silty clay loam that is moderately slowly permeable.

This soil is on side slopes or narrow divides below gently sloping Otley soils and above more strongly sloping Otley soils, moderately sloping to strongly sloping Clarinda, Lamoni, or Adair soils, or Colo-Ely silty clay loams, 2 to 5 percent slopes. In some areas near the valleys of major streams, it is closely associated with Ladoga soils.

Included with this soil in mapping are some dark-colored soils in small drainageways. Also included, at the heads of drainageways, are soils that have a thicker, darker surface layer and soils that have a gray subsoil that is wet and seepy during wet seasons. The subsoil is exposed in some areas at the shoulder of slopes or near sidehill drains.

This Otley soil is nearly all in row crops and is moderately well suited to them. Where row crops are planted, however, terraces and contour tillage are needed to help reduce the hazard of erosion. Runoff is rapid because of the moderate slopes and the slow absorption of moisture. Tilth is poor in many places; the surface layer often is hard and cloddy when dry. Tilth can be improved by adding barnyard manure, returning all crop residue to the soil, and growing more meadow crops. This soil is medium in organic-matter content. Additions of lime are needed. (Capability unit IIIe-1; woodland suitability group 1)

Otley silty clay loam, 9 to 14 percent slopes, moderately eroded (OtD2).—This soil generally has a dark grayish-brown plow layer 5 to 7 inches thick. The plow layer is the remaining surface layer mixed with a small amount of subsoil. The subsoil is dark-brown to yellowish-brown silty clay loam that is moderately slowly permeable.

This soil occurs on side slopes, generally below the gently sloping or moderately sloping Otley soils and above the strongly sloping Clarinda, Lamoni, or Adair soils, or above the Colo-Ely silty clay loams, 2 to 5 percent slopes, in narrow drainageways.

Included with this soil in mapping are small areas of Colo-Ely silty clay loams, 2 to 5 percent slopes, in drainageways. Also included, near the base of slopes and near sidehill drains, are soils that have a thicker and darker surface layer than this Otley soil. Some areas on the shoulders of slopes and at the heads of drainageways have the yellowish-brown subsoil exposed. At the heads of drainageways are a few areas of a soil that has a

mottled gray subsoil. Some of these areas are seasonally wet and seepy.

Nearly all of this Otley soil is in row crops, but a small acreage is in permanent pasture. This soil is moderately well suited to row crops. Because erosion is a serious hazard, contour tillage or terraces should be used to help reduce erosion in areas planted to row crops. (Capability unit IIIe-1; woodland suitability group 1)

Radford Series

The Radford series consists of stratified moderately well drained soils that developed from recent silty alluvial sediments. A buried dark-colored silty soil is at a depth of about 20 to 36 inches. Radford soils are on first bottoms adjacent to Nodaway and Colo soils. Slopes are 0 to 5 percent. The recent native vegetation of trees and prairie grasses has not influenced soil development. These soils are closely associated with Colo, Nodaway, Judson, and Ely soils. In some of the upland drainageways the Radford and Ely soils are mapped together as a complex.

In a typical profile the surface layer is stratified very dark grayish-brown and dark-brown silt loam 6 inches thick. It is light colored when dry. The surface layer is abruptly underlain by the substratum, which extends to a depth of 23 inches. This layer is stratified silt loam that has colors of very dark brown and very dark gray interbedded with brown. The next layer is the subsoil of a buried soil consisting of black, very dark gray, and pale-olive, friable to firm silty clay loam. It extends to a depth of 54 inches.

The Radford soils have a high available moisture holding capacity. Permeability is moderate in the upper part of these soils and is moderately slow in the lower part of the buried soil. The stratified surface layer and the dark buried soil are neutral to slightly acid. These Radford soils are low in available nitrogen and medium in available phosphorus and available potassium.

Typical profile of Radford silt loam, 700 feet east and 60 feet north of the southwest corner of the SW¼NE¼ section 12, T. 77 N., R. 13 W., on level flood plain:

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) and dark-brown (10YR 3/3) medium silt loam, very dark grayish brown (10YR 3/2) when kneaded; distinct strata of brown (10YR 5/3) at base of plow layer; moderate, fine, granular structure; friable; few fine concretions of iron; slightly acid; abrupt, smooth boundary.

C1—6 to 11 inches, stratified very dark grayish-brown (10YR 3/2) heavy silt loam and weak horizontal bands of grayish-brown (10YR 5/2) and brown (10YR 3/2) when kneaded; thick platy structure; friable; few fine concretions of iron; slightly acid; abrupt, smooth boundary.

C2—11 to 23 inches, heavy silt loam that is very dark grayish brown (10YR 3/2) and very dark gray (10YR 3/1) and is interbedded with half-inch strata of brown (10YR 5/3) coarse silt loam; very dark grayish brown (10YR 3/2) when kneaded; weak, thick, platy structure; friable; common, medium, distinct concretions of a dark-brown (7.5YR 2/2) oxide on plates; common fine concretions of iron and many fine concretions of manganese; neutral; abrupt, smooth boundary.

IIA11b—23 to 33 inches, black (N 2/0) medium silty clay loam; few, fine, prominent mottles of brown (10YR 5/3); moderate, fine and very fine, subangular blocky structure; friable to firm; few fine concretions of iron and manganese; neutral; clear, smooth boundary.

IIA12gb—33 to 45 inches, very dark gray (N 3/0) heavy silty clay loam; few, fine, prominent mottles of light olive brown (2.5Y 5/6) and few, fine, distinct mottles of dark grayish brown (2.5Y 4/2); moderate, very fine, subangular blocky and angular blocky structure; firm; sheen on some peds; few iron and manganese concretions as much as 5 millimeters in diameter; common fine concretions of iron and manganese; neutral; gradual boundary.

IIB2gb—45 to 54 inches, very dark gray (N 3/0) and pale-olive (5Y 6/3) heavy silty clay loam; few, fine, prominent, red (2.5YR 4/8), mottles, common, fine, distinct, olive (5Y 5/3) mottles, and few, fine, distinct, light olive-brown (2.5Y 5/4) mottles; strong, very fine, subangular blocky and angular blocky structure; firm; few, thin, patchy clay films; few iron and manganese concretions as much as 5 millimeters in diameter; common iron and manganese concretions; neutral.

In the upper 20 to 36 inches, the Radford soils are highly stratified with colors that range from very dark grayish brown to brown. These soils generally are silt loam, but in thin zones the content of sand is high. The sand content of the material above the buried soil ranges from 10 to 20 percent, and much of it is very fine in size. Horizons are very weakly defined, and in places the profile has only a plow layer. The buried soil is silty clay loam in texture and black or very dark gray in color. Olive-brown mottles increase in number as depth increases. These soils are slightly acid or neutral in the most acid part.

Radford soils differ from Nodaway soils in having a dark buried soil at about 24 to 30 inches below the surface layer. They are lighter colored, contain less clay, and are better drained than Colo soils. Radford soils are stratified, but Judson and Ely soils are not. Also, Radford soils have a thinner, lighter surface layer and a darker subsoil than the Judson and Ely soils.

Radford silt loam (Ra).—This soil occurs on level to nearly level bottom lands along the major streams in the county. Flood waters from these streams have deposited the lighter colored stratified silt loam on top of an older black soil. The profile of this soil is the one described as typical for the series. This soil is closely associated with the Nodaway and Amana soils, with Alluvial land-Nodaway complex, and in a few places with the Chequest, Zook, Wabash, and other dark-colored soils on bottom lands.

Included with this Radford soil in mapping are sandier areas where small streams or large upland drainageways have deposited their sediments uniformly on the bottom lands. A few areas are included where the buried soil is very dark gray instead of black.

This soil is used intensively for row crops. It is well suited to corn and soybeans. Most areas need tile lines to improve the drainage. In most years the slight to moderate overflow hazard does not seriously interfere with cropping. This soil is low in organic-matter content, but it is easily worked. (Capability unit I-2; woodland suitability group 9)

Radford-Ely complex, 2 to 5 percent slopes (ReB).—This complex is about two-thirds Radford soils and one-third Ely soils. The Radford soils have a light-colored surface layer underlain by a black buried soil at a depth of 20 to 36 inches. The Ely soils have a dark surface layer and are somewhat poorly drained.

The soils of this complex are in narrow upland drain-

ageways, generally where adjacent soils are moderately eroded to severely eroded. They also occur in areas where the sediments have been carried downstream and adjacent soils are not eroded. The Radford soils occur along the channels of the drainageways, and the Ely soils are on foot slopes. Also in the complex are a few poorly drained areas and some soils that have a loam surface layer.

Most of this complex is in trees, but in some areas trees have been removed and grass established. Where these soils are accessible to machinery, they are well suited to row crops such as corn and soybeans.

Land use is often determined by the adjoining upland soils. Some small and narrow areas are not accessible to modern farm machinery and should be left in permanent vegetation. Tilth is generally good, and crops grow moderately well. In many cultivated areas tile lines are needed on each side of the drainageway. Some areas can be protected from runoff by diversion terraces constructed at the base of the upland slopes. (Capability unit IIw-3; woodland suitability group 9)

Rubio Series

The Rubio series consists of poorly drained soils that developed from loess under a native vegetation of mixed prairie grasses and trees. These soils are on upland ridges and benches that have a slope of less than 1 percent. They occur with the Givin and Ladoga soils.

In a typical profile, the surface layer is very dark gray silt loam about 8 inches thick. The subsurface layer is dark-gray and grayish-brown silt loam that is distinctly light colored when dry. The subsoil, which extends to a depth of 53 inches, is dark gray in the upper part and grades to olive gray and dark olive gray. This layer is a firm, medium, and heavy silty clay loam and light silty clay. Yellowish-brown and light olive-brown mottles are present in the subsoil.

Rubio soils are slowly to very slowly permeable and have a high available moisture holding capacity. The surface layer is neutral to slightly acid, the subsurface layer is generally medium acid, and the subsoil is medium acid to strongly acid but grades to slightly acid to neutral as depth increases. These soils are very low in available nitrogen, low in available phosphorus, and very low in available potassium.

Typical profile of Rubio silt loam, 220 feet north and 1,800 feet west of the southeast corner section 24, T. 76 N., R. 11 W., on a nearly level upland divide:

Ap—0 to 8 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) when dry; few, fine, distinct mottles of grayish brown (10YR 5/2); weak, fine, subangular blocky and granular structure; friable; few, fine, soft concretions of strong-brown and black oxides; neutral; abrupt, smooth boundary.

A2—8 to 14 inches, dark-gray (10YR 4/1) and grayish-brown (10YR 5/2) silt loam, white (10YR 8/1) when dry; few, fine, distinct mottles of dark yellowish brown (10YR 4/4); moderate, medium, platy structure; friable; few to common, fine, soft concretions of black and strong-brown oxides; medium acid; abrupt, smooth boundary.

B21tg—14 to 18 inches, medium silty clay loam that has dark-gray (10YR 4/1) ped exteriors and gray (10YR 5/1) ped interiors; common, fine, distinct mottles of dark yellowish brown (10YR 4/4); strong, very fine, subangular blocky structure; firm; few, thin, discontinuous clay films; grainy ped coats that are nearly continuous, white (10YR 8/1) when dry; few, fine, soft, concretions of black and strong-brown oxides; strongly acid; clear, smooth boundary.

B22tg—18 to 30 inches, dark-gray (5Y 4/1) to olive-gray (5Y 5/2) heavy silty clay loam in upper part that grades to light silty clay; few, fine, prominent mottles of strong brown (7.5YR 5/8), common, fine, distinct mottles of yellowish brown (10YR 5/8) and light olive brown (2.5Y 5/6); moderate, medium, prismatic structure that breaks to strong, very fine, subangular blocky structure; firm; thin, continuous and some medium discontinuous clay films; few, fine, soft and moderately hard concretions of black and strong-brown oxides; few black clay balls as much as half inch in diameter in lower part; strongly acid; clear, smooth boundary.

B23tg—30 to 46 inches, heavy silty clay loam grading to medium silty clay loam in lower part; dark-gray (5Y 4/1) and olive-gray (5Y 4/2) ped exteriors and olive-gray (5Y 5/2) and light olive-gray (5Y 6/2) ped interiors; common, fine, distinct mottles of light olive brown (2.5Y 5/6) and yellowish brown (10YR 5/8); moderate, medium, prismatic structure that breaks to moderate, fine, subangular blocky structure; firm; thin continuous and few medium discontinuous clay films; few black (N 2/0) clay fills in root channels; few black (N 2/0) clay balls about one-fourth inch in diameter; few, fine, moderately hard concretions of black and strong-brown oxides; medium acid; gradual, smooth boundary.

B31tg—46 to 53 inches, olive-gray (5Y 4/2, 5/2) medium silty clay loam; common, fine, distinct mottles of light olive brown (2.5Y 5/6) and yellowish brown (10YR 5/8; weak, medium, prismatic structure that breaks to weak, medium, subangular blocky structure; firm; few very dark gray (5Y 3/1) clay films; few black clay fills in root channels; few black clay balls ¼ to ½ inch in diameter; few, fine, soft concretions of a black oxide and common, medium, strong-brown oxide stains and concretions of a soft oxide; neutral.

The A1 and Ap horizons range in color from very dark gray to very dark grayish brown. The A1 horizon is 6 to 10 inches thick. The A2 horizon ranges from dark gray to grayish brown in color and from 4 to 8 inches in thickness. The B horizon ranges from dark gray to light olive gray in color. Its maximum content of clay is 38 to 45 percent. In the B horizon are few to common, distinct to prominent mottles of fine olive, strong brown, yellowish brown, light olive brown, and dark yellowish brown. Clay films in the B horizon range from thin and continuous to thin and medium and patchy. Structure of the B horizon is strong to moderate subangular blocky. The solum is strongly acid in the most acid part. These soils are leached of carbonates to depths of 4 feet or more.

Rubio soils have a thinner and lighter colored surface layer than Sperry soils and less dark organic coatings in the upper part of the subsoil. Also, Rubio soils have grainy coats in the subsoil and Sperry soils do not. Rubio soils have grayer colors in the upper part of the subsoil than Givin soils, a more pronounced grayish subsurface layer and a more abrupt increase of clay between the subsurface layer and the subsoil.

Rubio silt loam (Ru).—This soil has a very dark gray surface layer 6 to 10 inches thick and a dark gray to grayish-brown subsurface layer 4 to 8 inches thick. It is level or slightly depressional and occurs as areas within the nearly level Givin or Keomah soils. Individual areas of Rubio soil range from 5 to 20 acres or more. Included with this soil in mapping are a few areas that have a very dark grayish-brown to dark grayish-brown surface layer.

This Rubio soil is used intensively for row crops. It is suited to corn, soybeans, small grains, forage grasses, and legumes. Although fertility is moderate, tilth may de-

teriorate where this soil is used intensively for row crops. Organic-matter content is moderate, and there is no erosion hazard.

Tile drainage is needed for maximum growth of crops, but without surface drainage, the tile may be satisfactory in all areas. Since this soil is normally acid, additions of lime also are required. (Capability unit IIIw–2; woodland suitability group 10)

Shelby Series

The Shelby series consists of moderately well drained soils that developed from clay loam glacial till under a native vegetation of prairie grasses. Some stones and pebbles occur in these soils. They are on low, convex, narrow interfluves and on sloping side slopes of 14 to 18 percent throughout the county. In some areas Shelby soils are mapped in a complex with the Adair soils or with the Lamoni soils. They are downslope from the loess-derived Otley soils and the weathered glacial till-derived Clarinda, Adair, and Lamoni soils.

In a typical profile the surface layer is very dark brown and very dark grayish-brown loam about 12 inches thick. The subsoil, which extends to a depth of 50 inches, is brown, friable loam in the upper 8 inches and brown, yellowish-brown, and light brownish-gray, firm, medium clay loam in the lower part. There are a few yellowish-brown, faint-brown, and brownish-yellow mottles in the lower part. The underlying material is a mottled yellowish-brown and light brownish-gray, firm, medium clay loam. It is mottled with yellowish brown and brownish yellow.

Shelby soils have moderately slow permeability and a high available moisture holding capacity. The surface layer typically is slightly acid. The subsoil is medium acid to slightly acid and grades to neutral at depths of about 30 inches or more. Shelby soils are low in available nitrogen and very low in available phosphorus and available potassium.

Typical profile of Shelby loam, 20 feet east and 90 feet south of the northwest corner of the NE¼NW¼ section 7, T. 77 N, R. 12 W., on a side slope of 15 percent that faces east:

A1—0 to 7 inches, very dark brown (10YR 2/2) to very dark grayish-brown (10YR 3/2) loam, very dark grayish brown (10YR 3/2) when kneaded; few, fine, faint mottles of dark yellowish-brown (10YR 4/4); weak, fine and very fine, subangular blocky structure that breaks to fine and very fine, granular structure; friable; slightly acid; clear, smooth boundary.

A3—7 to 12 inches, very dark grayish-brown (10YR 3/2) loam, very dark grayish brown (10YR 3/2) when kneaded; weak, fine and very fine, subangular blocky structure that breaks to weak, fine and very fine, granular structure; friable; few pebbles; slightly acid; clear, smooth boundary.

B1—12 to 20 inches, brown (10YR 4/3) loam; weak, fine and very fine, subangular blocky structure; friable; few pebbles; slightly acid; gradual, smooth boundary.

B21t—20 to 27 inches, light clay loam that has brown (10YR 4/3) ped exteriors and dark yellowish-brown (10YR 4/4) ped interiors; few, fine, faint mottles of yellowish brown; thin, discontinuous clay films; weak, fine and very fine, subangular blocky structure; firm; few, fine, distinct concretions of a strong-brown oxide; few pebbles and stones; medium acid; gradual, smooth boundary.

B22t—27 to 40 inches, yellowish-brown (10YR 5/4) light clay loam; common, fine, faint mottles of yellowish brown (10YR 5/4) and few, fine, faint mottles of brown (10YR 5/3); moderate, fine and very fine, subangular blocky structure; firm; thin, discontinuous, dark-brown clay films; few, fine, black concretions of manganese; slightly acid; few pebbles and stones; gradual, smooth boundary.

B3t—40 to 50 inches, yellowish-brown (10YR 5/4) and light brownish-gray (2.5Y 6/2) medium clay loam; few, fine, distinct mottles of brownish yellow (10YR 6/8); weak, medium and coarse, subangular blocky structure; firm; few, thin, discontinuous clay films; common, fine, black manganese concretions; neutral; few pebbles and stones; gradual, smooth boundary.

C—50 to 60 inches, yellowish-brown (10YR 5/4) and light brownish-gray (2.5Y 6/2) medium clay loam; few, fine, distinct mottles of brownish yellow (10YR 6/8) and common, fine, faint mottles of yellowish brown (10YR 5/6); massive (structureless); firm; few pebbles and stones; common, fine, black concretions of manganese; neutral.

The A horizon ranges from light loam to heavy loam. It is black or very dark brown in uneroded areas and very dark grayish brown in moderately eroded areas. Below the surface is a mottle-free zone 10 or more inches thick. In some places grayish mottles occur at a depth of 20 to 30 inches. The B horizon averages from 32 to 35 percent clay in content, including the thin horizons that are as much as 38 percent clay. The C horizon is typically clay loam, but it ranges to loam in places. The depth to carbonates ranges from 3 feet to nearly 6 feet.

Shelby soils have a darker and thicker surface layer than Gara soils and lack the grayish subsurface layer. They have less clay in the subsoil than Adair soils and lack the red colors. They have a less gray subsoil and substratum and a lower clay content in the subsoil than Clarinda soils, which lack the stones and pebbles that are present in the Shelby soils.

Shelby loam, 14 to 18 percent slopes, moderately eroded (ShE2).—This soil occurs in bands on the lower side slopes in the strongly dissected upland prairie areas of the county. It generally is below the strongly sloping Adair soils and above Colo-Ely silty clay loams, 2 to 5 percent slopes, and Radford-Ely complex, 2 to 5 percent slopes.

This soil has a profile similar to the one described as typical for the series. Where there is a plow layer, it is very dark grayish brown, is 5 to 7 inches thick, and consists of the original surface layer mixed with some of the subsoil.

Included with this soil in mapping are areas near the Adair or other soils upslope that have a clay loam surface layer. Also included are some severely eroded areas that have the dark-brown subsoil exposed. Since these areas normally are firm clay loam, it is somewhat difficult to prepare suitable seedbeds on them. Application of manure improves tilth and increases absorption of water in these areas. Some less eroded areas that have a dark surface layer as much as 12 inches thick are also included. Other inclusions are of less sloping soils and many small upland drainageways that generally are crossable with farm machinery.

This Shelby soil is better suited to forage grasses, legumes, and permanent pasture than to row crops.

Where it is used for row crops, this soil should be tilled on the contour. Terraces generally are not used. Because runoff is rapid, this soil is erodible in cultivated areas. It is low to medium in organic-matter content. Additions of lime are required. (Capability unit IVe–3, woodland suitability group 2)

Sogn Series

The Sogn series consists of well drained to somewhat excessively drained soils that have limestone bedrock at a depth of 10 to 20 inches. These soils developed from loamy materials containing flags of limestone and some sandstone. Native vegetation was mixed prairie grasses and trees. Sogn soils are on convex upland slopes of 15 to 30 percent adjacent to the major streams of the county.

In a typical profile the surface is covered with a thin layer of decayed leaves and twigs. The surface layer, about 9 inches thick, is very dark gray and very dark grayish-brown loam. This layer grades to a dark-brown and brown, friable loam. The underlying material is unconsolidated limestone bedrock.

Sogn soils are rapidly permeable and have a very low available moisture holding capacity. The loamy material over the limestone bedrock is generally neutral but ranges to slightly acid in places. These soils are very low in available nitrogen and available phosphorus and low in available potassium.

Typical profile of Sogn loam, 900 feet east and 100 feet north of the southwest corner of the SE¼ section 28, T. 75 N., R. 10 W., on a side slope of 30 percent that faces southwest:

O2—½ inch to 0, organic layer of decayed leaves and small twigs; abrupt boundary.

A1—0 to 6 inches, very dark gray (10YR 3/1) loam, very dark gray (10YR 3/1) when kneaded; weak, fine, subangular blocky structure that breaks to weak, fine, granular structure; friable; numerous fine roots; few fine concretions of iron and manganese; rounded fragments of limestone and sandstone about 1 inch in diameter; neutral; clear, smooth boundary.

A3—6 to 9 inches, very dark gray (10YR 3/1) and very dark grayish-brown (10YR 3/2) heavy loam, very dark grayish brown (10YR 3/2) when kneaded; weak, fine, subangular blocky structure; friable; numerous fine roots; few fine concretions of iron; rounded limestone flags 2 to 4 inches long; some small gravel-size fragments of sandstone; neutral; clear, smooth boundary.

AB—9 to 15 inches, dark-brown (10YR 3/3) and brown (10YR 4/3) loam; weak, fine, subangular blocky structure; friable; few fine and medium concretions of iron and manganese; discontinuous flags of limestone and sandstone as much as 6 inches across; soil between the flags; gravel-size fragments of sandstone; gravel; neutral; clear, smooth boundary.

IIR—15 inches +, unconsolidated bedrock, mostly limestone but some sandstone.

The A1 horizon ranges from very dark brown to very dark gray and very dark grayish brown in color and from loam to heavy sandy loam in texture. The B horizon, where present, ranges from dark brown to brown in color, from heavy loam to light clay loam in texture, and from 5 to 12 inches in thickness. The solum contains fragments of bedrock, predominantly limestone, though there is some calcareous sandstone. The R horizon generally occurs at a depth of 15 inches or less and consists mainly of fractured limestone. Outcrops of limestone bedrock are common. The solum is neutral to slightly acid.

Sogn soils are shallower to bedrock than Dunbarton soils and lack the reddish colored clayey subsoil. Sogn soils lack the clayey subsoil of the Gosport soils that is underlain by shale bedrock at a depth of 20 to 36 inches.

Sogn soils, 15 to 30 percent slopes (SoF).—These soils have a very dark gray to very dark grayish-brown loam surface layer 7 to 15 inches thick. They formed in a thin layer of medium-textured material over fractured limestone bedrock. Bedrock is generally within 15 inches of the surface, but on most of the upper slopes are small areas where the depth to bedrock is at a depth of as much as 24 inches.

These soils are in scattered areas on the steep slopes that border streams. They generally occur below the Lindley or Keswick soils, and a few areas are below strongly sloping Clinton or Dunbarton soils. Outcrops of limestone bedrock are common.

Included with these soils in mapping are some areas that are underlain by calcareous sandstone bedrock.

These soils generally are used for trees, but a small acreage is in permanent pasture. The soils are too shallow and slopes generally are too steep for cultivation. They are well suited to their present use and to plantings for wildlife. A few areas are suited to pasture where grazing is limited. Some areas may have potential as a source of limestone or crushed rock. (Capability unit VIIs–1; woodland suitability group 6)

Sparta Series

The Sparta series consists of excessively drained soils that developed from eolian sands or sands reworked by wind. The native vegetation was prairie grasses. These soils are on complex slopes on upland ridges and side slopes and high stream benches near the major rivers. They occur only in a complex with the Dickinson soils on stream benches and ridgetops of 2 to 5 percent slopes or in a complex with the Dickinson and Ladoga soils on side slopes of 5 to 14 percent.

In a typical profile the surface layer is very dark grayish-brown and dark-brown loamy fine sand about 13 inches thick. The subsoil, about 19 inches thick, is very dark grayish brown and dark brown in the upper part and yellowish brown in the lower part. It is friable to loose loamy fine sand and fine sand. The substratum is yellowish-brown sand that has a few dark yellowish-brown mottles.

Sparta soils have a very low available moisture holding capacity. They are rapidly permeable and excessively drained. The surface layer is medium acid to neutral, the subsoil typically is medium acid, and the substratum is slightly acid to neutral. These soils are very low to low in available nitrogen and very low in available phosphorus and available potassium.

Typical profile of a Sparta loamy fine sand, 340 feet east and 2,620 feet south of the northwest corner section 18, T. 76 N., R. 13 W., in a cultivated field on a convex slope of 3 percent:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) loamy fine sand, very dark grayish brown (10YR 3/2) when kneaded; few, fine, faint mottles of dark brown to brown (10YR 4/3); weak, fine, granular structure; very friable; medium acid; clear, smooth boundary.

A3—8 to 13 inches, very dark grayish-brown (10YR 3/2) and dark-brown (10YR 3/3) loamy fine sand; weak, fine, granular structure; very friable; medium acid; gradual, smooth boundary.

B1—13 to 18 inches, loamy fine sand that dominantly is very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) in the upper part but grades to yellowish-brown (10YR 5/6) as depth increases; weak, fine, granular structure; very friable; medium acid; gradual, smooth boundary.

B2—18 to 26 inches, yellowish-brown (10YR 5/6) fine sand; very weak, medium, angular blocky structure that

breaks to single grain (structureless); very friable; some clay bridges between sand grains; medium acid; gradual, smooth boundary.

B3—26 to 32 inches, yellowish-brown (10YR 5/6) fine sand; very weak, medium to coarse, subangular blocky structure that breaks to single grain (structureless); slightly coherent to loose; some clay bridges between sand grains; medium acid; gradual, smooth boundary.

C—32 to 55 inches, yellowish-brown (10YR 5/8) fine to medium sand; few, fine and medium, faint mottles of dark yellowish brown (10YR 4/4); single grain (structureless); loose to slightly coherent; some grains of coarse and very coarse sand; few, fine, hard concretions of a black oxide; medium acid; gradual, smooth boundary.

The A1 horizon ranges from 10 to 15 inches in thickness, from very dark brown to very dark grayish brown in color, and from loamy fine sand to fine sandy loam in texture. The B horizon ranges from dark brown to brown to strong brown in color and from loamy fine sand to fine sand in texture. Bands of iron commonly are weakly expressed or are not visible above a depth of 40 inches. The sand grains in the lower part of the solum are coated with iron oxides in many places.

Sparta soils have a darker colored, thicker surface layer than the Chelsea soils and a sandier, more weakly developed subsoil than the Dickinson soils. Loose sand is at a shallower depth in the Sparta soils than in the Dickinson.

Sperry Series

The Sperry series consists of very poorly drained soils developed from loess. Water ponds on these soils unless they are drained. These soils are in depressional areas on the broad upland ridgetops throughout the county. Individual areas typically are 1 to 2 acres or less. The native vegetation was prairie grasses and sedges tolerant of excess wetness.

In a typical profile the surface layer is black, very dark gray, and dark-gray silt loam about 12 inches thick. The subsurface layer is dark-gray silt loam to light silty clay loam that is distinctly light colored when dry. The subsoil, which begins at a depth of about 20 inches and extends to a depth of 60 inches, is very dark gray and dark-gray to gray, friable silty clay in the upper 12 inches. Below 32 inches the subsoil is gray, light-gray, or olive-gray, firm medium to light silty clay loam. Strong-brown, grayish-brown, and light olive-brown mottles are present in the subsoil.

Sperry soils are slowly to very slowly permeable and have a high available moisture holding capacity. The surface layer is medium acid to slightly acid, the subsurface layer is medium acid to strongly acid, and the subsoil is medium acid to slightly acid but grades to neutral with increasing depth. These soils are low in available nitrogen and very low in available phosphorus and available potassium.

Typical profile of Sperry silt loam, 1,950 feet south of the northwest corner section 28, T. 77 N., R. 11 W., in a slightly depressional part of a level upland divide:

Ap—0 to 8 inches, black (10YR 2/1) heavy silt loam, very dark gray (10YR 3/1) when kneaded; weak, cloddy structure breaking to weak, fine, granular structure; friable; medium acid; abrupt, smooth boundary.

A1—8 to 12 inches, very dark gray (10YR 3/1) and dark-gray (10YR 4/1) silt loam, very dark gray (10YR 3/1) when kneaded; moderate, thin, platy structure that breaks to moderate, fine, granular structure; friable; few grayish-brown (10YR 5/2) grainy coatings; very few, fine, soft concretions of a dark-brown oxide; medium acid; clear, smooth boundary.

A21—12 to 15 inches, dark-gray (10YR 4/1) silt loam, dark gray (10YR 4/1) when kneaded; few plates coated with very dark gray (10YR 3/1); common, fine, distinct mottles of olive brown (2.5Y 4/4); weak, thin, platy structure; friable; few, fine, soft concretions of dark-brown and strong-brown oxides; discontinuous, gray (10YR 6/1, dry), grainy coats on peds; strongly acid; clear smooth boundary.

A22—15 to 20 inches, dark-gray (10YR 4/1) silt loam to light silty clay loam; common, fine, distinct mottles of light olive brown (2.5Y 5/4); moderate, fine, subangular blocky structure with some horizontal cleavage; friable; few, fine, soft concretions of a strong-brown oxide; continuous gray (10YR 6/1, dry) grainy ped coats; strongly acid; abrupt, smooth boundary.

B21tg—20 to 27 inches, medium silty clay that has very dark-gray (10YR 3/1) ped exteriors and dark gray (10YR 4/1) ped interiors; common, fine, distinct mottles of strong brown (7.5YR 5/6) and few, fine, distinct mottles of grayish brown (2.5Y 5/2); weak, fine, prismatic structure that breaks to moderate to strong, very fine, subangular blocky structure; firm; thick nearly continuous clay films; medium acid; clear, smooth boundary.

B22tg—27 to 32 inches, light silty clay that has dark-gray (10YR 4/1) to gray (10YR 5/1) ped exteriors and olive-gray (5Y 5/2) ped interiors; common, fine, prominent mottles of strong brown (7.5YR 5/6); moderate, fine, prismatic structure that breaks to moderate, very fine, subangular blocky structure; firm; nearly continuous clay films; medium acid; clear, smooth boundary.

B23tg—32 to 43 inches, gray (5Y 5/1) and olive-gray (5Y 5/2) medium silty clay loam; few, fine, distinct mottles of strong brown (7.5YR 5/6) and light olive brown (2.5Y 5/4); weak, medium, prismatic structure that breaks to weak, medium, subangular blocky structure; firm; thin, discontinuous, dark-gray (10YR 4/1) clay films on prism faces; few dark-gray (10YR 4/1) clay fills in old root channels; few, fine, soft concretions of black and dark brown oxides; slightly acid; clear, smooth boundary.

B3tg—43 to 60 inches, mottled gray to light-gray (5Y 6/1), yellowish-brown (10YR 5/6), and strong-brown (7.5YR 5/6) light to medium silty clay loam; weak, medium, prismatic structure; firm; many very dark gray (10YR 3/1) and dark-gray (10YR 4/1) clay fills in old root channels; few, fine, soft concretions of black and dark-brown oxides; slightly acid; gradual, smooth boundary.

The A1 horizon ranges from black to very dark gray in color and from 10 to 14 inches in thickness. The A2 horizon ranges from very dark gray to dark gray in color and from 4 to 8 inches in thickness. The A horizon ranges from silt loam to light silty clay loam. The maximum content of clay in the B horizon is 42 to 48 percent. The solum is strongly acid to medium acid in the most acid part.

Sperry soils have a thinner, less clayey surface layer than Taintor soils and a light-colored, grayish subsurface layer that the Taintor soils lack. The subsoil of Sperry soils contains slightly more clay than that of the Taintor soils. Sperry soils have a thinner surface layer and more clay in the subsoil than Vesser soils. They have a thicker surface layer than Rubio soils, which lack grainy ped coats in the subsoil. Dark clay coats are more evident in Sperry soils than in Rubio or Vesser soils. Sperry soils have a slightly lower content of fine sand than Humeston soils, and typically the clay content remains less constant as depth increases. The increase in clay from the subsurface layer to the subsoil is more abrupt in the Sperry soils than in the Humeston.

Sperry silt loam (Sp).—This soil has a black to very dark gray surface layer 8 to 10 inches thick. The distinct very dark gray to dark-gray subsurface layer is lighter colored when dry. The subsoil is slowly to very slowly permeable and is plastic and sticky when wet.

This soil is level to slightly depressional and occurs in areas of 1 to 2 acres within larger areas of the level Taintor soils and the nearly level Mahaska soils. It is cultivated with the associated Mahaska and Taintor soils.

This soil is used intensively for row crops. Where properly drained, it is suited to corn, soybeans, small grains, forage grasses, and legumes. Crops grow moderately well on this soil, but they often turn yellow when rainfall is above normal because then they lack air and nitrogen.

Runoff from adjoining soils collects and forms ponds in depressional areas. Tile drains usually function in this soil, but surface drains are also needed to remove ponded water. This soil is acid unless recently limed, and needs additions of lime for good plant growth. (Capability unit IIIw-2; woodland suitability group 10)

Taintor Series

The Taintor series consists of poorly drained soils that developed from loess under prairie grasses and sedges tolerant of excess wetness. These soils are nearly level and occur on upland ridgtops and high stream benches. They are in areas that surround depressional spots of Sperry soils. Taintor soils are bordered by the Mahaska soils, which are at a slightly lower elevation.

In a typical profile the surface layer is black silty clay loam and silty clay about 17 inches thick. The subsoil extends to a depth of 60 inches. It is very dark gray to dark-gray, firm silty clay in the upper part and olive-gray, firm medium to light silty clay loam below a depth of about 28 inches. The underlying material is light olive-gray silt loam. Mottles occur in the subsoil and underlying material.

Taintor soils are moderately slow in permeability and have a high available moisture holding capacity. The surface layer is slightly acid to medium acid, the subsoil is typically slightly acid, and the substratum is slightly acid to neutral. Taintor soils are medium in available nitrogen and very low in available phosphorus and potassium.

Typical profile of Taintor silty clay loam, 385 feet north and 51 feet east of the southwest corner of the SE¼SW¼ section 27, T. 77 N., R. 10 W., on a level upland divide:

Ap—0 to 6 inches, black (N 2/0) medium to heavy silty clay loam, very dark gray (10YR 3/1) when dry; moderate, fine and medium, angular blocky structure; firm; slightly acid; abrupt, smooth boundary.

A1—6 to 12 inches, black (N 2/0) heavy silty clay loam to light silty clay; moderate, very fine, subangular blocky and moderate, fine, granular structure; firm; medium acid; gradual, smooth boundary.

A3—12 to 17 inches, black (N 2/0) light silty clay, very dark gray (10YR 3/1) when dry; common, fine, very faint mottles of very dark grayish brown (2.5Y 3/2) inside peds; moderate, very fine, subangular blocky with some moderate, fine, granular structure; firm; few, fine, hard concretions of an oxide; medium acid; gradual, smooth boundary.

B1—17 to 22 inches, light silty clay that has very dark gray (10YR 3/1) ped exteriors and very dark grayish-brown (2.5 Y 3/2) ped interiors, dark gray (10YR 4/1) when dry; common, fine, faint mottles of light olive brown (2.5Y 5/4); weak, fine, subangular blocky structure that breaks to moderate, very fine, subangular blocky structure; firm; few, fine, soft concretions of an oxide; slightly acid; gradual, smooth boundary.

B21tg—22 to 28 inches, light silty clay that has dark-gray (5Y 4/1) ped exteriors and light olive-brown (2.5Y 5/4) ped interiors; common, fine, distinct mottles of yellowish brown (10YR 5/6); weak, fine, prismatic structure that breaks to moderate, fine and very fine, subangular blocky structure; firm; few vertical streaks of very dark gray (N 3/0) stains; common, thin, discontinuous clay films; common, fine, hard and a few, fine, soft concretions of an oxide between depths of 26 and 28 inches; slightly acid; clear, smooth boundary.

B22tg—28 to 34 inches, medium silty clay loam that has olive-gray (5Y 5/2) ped exteriors and mottled olive-gray (5Y 5/2) and yellowish-brown (10YR 5/6) ped interiors; moderate, coarse, prismatic structure that breaks to moderate, fine, subangular blocky structure; firm; common, discontinuous, dark-gray (5Y 4/1) clay films on blocky peds and prism faces; many, fine, slightly hard and few, medium, soft concretions of an oxide; neutral; clear, wavy boundary.

B31tg—34 to 40 inches, olive-gray (5Y 5/2) medium silty clay loam; common, fine, faint mottles of light olive brown (2.5Y 5/4); a faint, wavy, horizontal band of strong brown (7.5YR 5/8); moderate, coarse, prismatic structure that breaks to moderate, fine and medium, subangular blocky structure; firm; few, distinct, thin, patchy, dark-gray (5Y 4/1) clay films on prism faces; common, fine, hard concretions of an oxide; neutral; gradual, smooth boundary.

B32tg—40 to 60 inches, light silty clay loam that has olive-gray (5Y 5/2) ped exteriors and light olive-gray (5Y 6/2) ped interiors; common, fine, distinct, yellowish-brown (10YR 5/6) mottles; moderate, coarse, prismatic structure; firm; common prominent segregations of strong brown (7.5YR 5/6); very few, thin, dark-gray (5Y 4/1) clay films on prism faces; mildly alkaline; diffused, wavy boundary.

C—60 to 70 inches, light olive-gray (5Y 6/2) silt loam; massive (structureless); firm; many, fine, prominent segregations of strong brown (7.5Y 5/8); mildly alkaline.

The A horizon ranges from 15 to 20 inches in thickness. The B horizon ranges from very dark gray to light olive gray and has yellowish-brown and olive-brown mottles throughout. The B horizon ranges from heavy silty clay loam to light silty clay and has a maximum clay content of about 38 to 45 percent. The clay maximum is generally in the A3 or B1 horizon. These soils are medium acid to slightly acid in the most acid part. Acidity decreases below a depth of about 30 inches, and the B3 horizon is neutral or mildly alkaline. Secondary carbonates may occur at a depth of only 48 inches, but they are generally absent.

Taintor soils have a grayer subsoil than Mahaska soils and a somewhat higher clay content in the subsoil and surface layer. Taintor soils have a thicker, darker, finer textured surface layer than the Sperry soils, and they lack the grayish subsurface layer.

Taintor silty clay loam (Ta).—This soil has a black surface layer 15 to 21 inches thick. The subsoil is very dark gray to olive-gray silty clay loam to silty clay.

This soil is nearly level and generally occurs in broad areas surrounded by the nearly level and gently sloping Mahaska soils. In some areas, however, this soil occurs with nearly level Givin soils. It surrounds the slightly depressional Sperry soils in places.

Included with this soil in mapping are some Sperry soils in areas too small to delineate. Some areas are also included that have a browner surface layer than this Taintor soil and are slightly better drained. In a few areas the surface layer is silty clay.

This Taintor soil is well suited to intensive row cropping. Organic-matter content is high, and tilth is generally good.

Because of poor surface drainage and the moderately slow permeability of the subsoil, supplemental drainage is needed. This soil puddles easily if tilled when too wet. Tile drains function well in it. There is little or no water erosion on this soil, but soil blowing sometimes occurs in areas that are plowed in fall. This soil dries after rains somewhat more slowly than the surrounding Mahaska soils and warms more slowly in spring. Fall plowing helps promote granulation and faster warming in spring. (Capability unit IIw–2; woodland suitability group 10)

Taintor silty clay loam, benches (Tb).—This soil is similar to Taintor silty clay loam, but it occurs on level loess-covered benches underlain by alluvium at a depth of 10 to 15 feet. It is generally surrounded by nearly level and gently sloping Mahaska soils that occur on the same benches. The most extensive areas are south and east of Sigourney near the North Skunk River. Other areas are adjacent to the valleys of the Skunk Rivers and some other major streams in the county. Included with this soil in mapping are small areas of depressional soils.

This soil is well suited to intensive row cropping. Organic-matter content is high, and tilth is good. Because surface drainage is slow and permeability is moderately slow, drainage is needed for good crop growth. Tile drains function well. If this soil is tilled when too wet, it puddles. Erosion is little or none, but soil blowing occurs in areas that are plowed in fall. This soil dries more slowly than the surrounding soils and warms more slowly in spring. Fall plowing helps promote granulation and faster warming in spring. (Capability unit IIw–2; woodland suitability group 10)

Tuskeego Series

The Tuskeego series consists of poorly drained soils that developed from silty alluvium that contains little sand. The native vegetation was trees and prairie grasses tolerant of excess wetness. These soils are on slopes of less than 1 percent on low stream benches and high second bottoms.

In a typical profile the surface layer is very dark gray silt loam about 7 inches thick. The subsurface layer is dark-gray and gray silt loam that is distinctly light colored when dry. The subsoil extends to a depth of 55 inches. It is firm silty clay loam and silty clay that ranges from grayish brown and gray and dark gray in the upper 14 inches to grayish brown and light brownish gray below. Yellowish-brown and dark yellowish-brown mottles occur in the subsoil.

Tuskeego soils are slowly to very slowly permeable and have a high available moisture holding capacity. The surface layer is medium acid. The subsurface layer and subsoil are mostly medium acid to strongly acid, but they grade to slightly acid and neutral as depth increases. Tuskeego soils are low in available nitrogen, medium in available phosphorus, and very low in available potassium.

Typical profile of Tuskeego silt loam, 400 feet east and 970 feet south of the northwest corner of the NW¼-NW¼ section 31, T. 75 N., R. 10 W., on the nearly level flood plain along the North Skunk River:

Ap—0 to 7 inches, very dark gray (10YR 3/1) silt loam; few, fine, faint mottles of dark yellowish brown (10YR 4/4); very weak, medium to thick, platy structure that breaks to weak, very fine and fine, granular structure; friable; few, fine, soft concretions of strong-brown and black oxides; medium acid; abrupt, smooth boundary.

A2—7 to 12 inches, medium silt loam that has gray (10YR 5/1) ped exteriors and dark-gray (10YR 4/1) ped interiors; many, fine, distinct mottles of dark yellowish brown (10YR 4/4); weak, medium to thick, platy structure that breaks to weak, very fine, granular structure; very friable; common, fine, soft concretions of strong-brown and black oxides; medium acid; clear, smooth boundary.

B1t—12 to 18 inches, grayish-brown (10YR 5/2) and gray (10YR 5/1) light to medium silty clay loam; common, fine, distinct mottles of dark yellowish brown (10YR 4/4); weak, fine, subangular blocky structure; firm; few, thin, discontinuous clay films; distinct grainy coatings, white (10YR 8/1) when dry; common, fine, soft concretions of a strong-brown oxide and few fine concretions of a black oxide; medium acid; clear, smooth boundary.

B21tg—18 to 26 inches, medium silty clay loam that has dark-gray (10YR 4/1) ped exteriors and dark-gray (10YR 4/1) and dark grayish-brown (10YR 4/2) ped interiors; common, fine, faint mottles of dark yellowish brown (10YR 4/4); weak, medium, prismatic structure that breaks to weak, fine and moderate, very fine subangular blocky structure; firm; common, thin, indistinct clay films; common, fine, moderately hard concretions of a strong-brown oxide and few, fine, hard concretions of a black oxide; distinct discontinuous grainy ped coats, white (10YR 8/1) when dry; medium acid; gradual, smooth boundary.

B22tg—26 to 39 inches, dark-gray (10YR 4/1) and grayish-brown (10YR 5/2) heavy silty clay loam to silty clay; common, fine, distinct mottles of yellowish brown (10YR 5/6); weak, medium, prismatic structure that breaks to moderate, very fine, subangular blocky structure; firm; common, thin and medium, discontinuous clay films common, fine, moderately hard concretions of strong brown and soft black oxides and a few hard concretions of a black oxide, hard concretions are 3 to 4 millimeters in diameter; distinct, discontinuous, grainy ped coats, white (10YR 8/1) when dry; medium acid; gradual, smooth boundary.

B3tg—39 to 55 inches, grayish-brown (10YR 5/2) to light brownish-gray (10YR 6/2) silty clay loam; common, fine, distinct mottles of dark yellowish brown (10YR 4/4); weak, medium, prismatic structure that breaks to very weak, fine, subangular blocky structure; firm; few, thin, discontinuous clay films and a few very dark gray (10YR 3/1) clay fills in old root channels; few, fine, soft concretions of a strong-brown oxide; few, thin, distinct, discontinuous, grainy coats in upper part of horizon, white (10YR 8/1) when dry; neutral; gradual, smooth boundary.

The A1 horizon ranges from very dark gray to very dark grayish brown in color and from 6 to 8 inches in thickness. The A2 horizon ranges from dark gray or dark grayish brown to grayish brown in color and from 4 to 10 inches in thickness. The B horizon ranges from dark gray to light olive gray and is mottled with yellowish brown. The maximum clay content of the subsoil generally ranges from 38 to 45 percent. The solum is medium acid to strongly acid in the most acid part.

Tuskeego soils have a thinner dark surface layer and less dark organic coatings in the upper part of the subsoil than Humeston soils and are more acid in many places. They are more gray and intensely mottled in the subsoil than Koszta soils and have more clay in the subsoil. Tuskeego soils contain more fine sand than Rubio soils. They generally have more clay in the substratum than Rubio soils or, in places, are stratified with fine lenses of sand and silt below a depth of 40 inches.

Tuskeego silt loam (Tu).—This soil has a very dark grayish-brown to dark-gray plow layer 5 to 7 inches thick. The subsurface layer is 4 to 10 inches thick and

consists of dark-gray silt loam that is lighter colored when dry. The subsoil is generally dark-gray to grayish-brown silty clay loam.

This soil occurs on low stream terraces that are level to slightly depressional. It is closely associated with the Koszta and Vesser soils and is generally surrounded by Chequest, Wabash, or Amana soils of the first bottoms.

Included with this soil in mapping are areas that have a lighter colored plow layer. The plow layer has been mixed with parts of the subsurface layer. These soils are sometimes ponded for short periods after rains.

This soil is used intensively for row crops. Where properly drained, it is suited to corn and soybeans. Tile lines are generally effective, but require close spacing. Some surface drains are needed to remove excess surface water.

Crops grow fairly well on this soil. Tilth is generally good, unless the soil is worked when too wet. Additions of lime are required for good plant growth. (Capability unit IIIw-2; woodland suitability group 10)

Vesser Series

The Vesser series consists of somewhat poorly to poorly drained soils that developed from silty alluvium under a native vegetation of prairie grasses and trees tolerant of excess wetness. Most of the Vesser soils are on low foot slopes and stream benches, but some are on first bottoms throughout the county. Slopes range from 0 to 5 percent.

In a typical profile the surface layer is very dark brown and black silt loam about 13 inches thick. The subsurface layer, which extends to a depth of 23 inches, is dark-gray, dark grayish-brown, and olive-gray silt loam. This layer is distinctly light colored when dry. The subsoil is olive-gray firm silty clay loam that is mottled with yellowish brown, olive brown, light olive brown, and dark yellowish brown.

The Vesser soils are moderately slowly permeable and have a high available moisture holding capacity. The surface layer is generally medium acid. The subsurface layer is medium acid to strongly acid, and the subsoil is medium acid to slightly acid in most places. These soils are low in available nitrogen and very low in available phosphorus and available potassium.

A typical profile of Vesser silt loam, 365 feet west and 340 feet south of the northeast corner of the NW¼NE¼ section 16, T. 77 N., R. 10 W., in a cultivated field on the nearly level flood plain along the South English River:

Ap—0 to 7 inches, very dark brown (10YR 2/2) heavy silt loam; weak, fine, granular structure; friable; few, fine, soft concretions of a strong-brown oxide; medium acid; clear, smooth boundary.

A1—7 to 13 inches, black (10YR 2/1) heavy silt loam, weak, fine and very fine, granular and weak, fine, subangular blocky structure; friable; few, fine, soft concretions of a strong-brown oxide; medium acid; gradual, smooth boundary.

A21—13 to 17 inches, heavy silt loam that has dark-gray (10YR 4/1) exteriors and very dark grayish-brown (10YR 3/2) to dark grayish-brown (10YR 4/2) interiors; dark grayish brown (10YR 4/2) when kneaded; common, fine, distinct mottles of dark yellowish brown (10YR 4/4); weak, medium and thick, platy structure that breaks to weak, very fine to fine, subangular blocky structure; friable; distinct, discontinuous, grainy coats that are light gray (10YR 7/1) when dry; common, fine, soft concretions of a brown oxide and few, fine, soft concretions of a black oxide; strongly acid; gradual, smooth boundary.

A22—17 to 23 inches, dark grayish-brown (10YR 4/2) and olive-gray (5Y 5/2) silt loam; many, fine, distinct mottles of yellowish brown (10YR 5/6); weak, medium and fine, subangular blocky structure; friable; very few, thin, discontinuous clay films; few, thin, very dark gray (10YR 3/1) clay fills in old root channels; discontinuous, distinct, grainy coats that are light gray (10YR 7/1) when dry; common, fine, soft concretions of a strong-brown oxide and few, fine, soft concretions of a black oxide; strongly acid; gradual, smooth boundary.

B1t—23 to 31 inches, light silty clay loam that has olive-gray (5Y 5/2) ped exteriors and dark grayish-brown (2.5Y 4/2) ped interiors; common, fine, distinct mottles of yellowish brown (10YR 5/6) and common, fine, faint mottles of olive brown (2.5Y 4/4); weak, medium, prismatic structure that breaks to weak, fine, subangular blocky structure; friable; few, thin, very dark gray (10YR 3/1) clay fills in old root channels; nearly continuous, distinct, grainy coats that are light gray (10YR 7/1) when dry; common, fine, soft concretions of a strong-brown oxide and few, fine, soft concretions of a black oxide; medium acid; gradual, smooth boundary.

B2tg—31 to 47 inches, light to medium silty clay loam that has olive-gray (5Y 5/2) ped exteriors and light olive-gray (5Y 6/2) ped interiors; common, fine, distinct mottles of yellowish brown (10YR 5/6); weak, medium, prismatic structure that breaks to weak, medium, subangular and angular blocky structure; firm; few, distinct, discontinuous grainy coats that are light gray (10YR 7/1) when dry; common, thin, discontinuous clay films; few very dark gray (N 3/0) clay fills in old root channels; few, fine, soft concretions of strong-brown and black oxides; slightly acid; gradual, smooth boundary.

B3g—47 to 58 inches, olive-gray (5Y 5/2) light silty clay loam; common, fine, distinct mottles of light olive brown (2.5Y 5/4) and dark yellowish brown (10YR 4/4); weak, coarse, prismatic structure; firm; very few, fine, soft concretions of strong-brown and black oxides; few very dark gray (N 3/0) clay fills in old root channels; neutral.

The A1 or Ap horizon ranges from black or very dark gray to very dark brown and very dark grayish brown in color and from 10 to 14 inches in thickness. The A2 horizon ranges from very dark grayish brown to grayish brown and olive gray in color and from 10 to 20 inches in thickness. The B horizon ranges from dark grayish brown to light olive gray and has common yellowish-brown and olive-brown mottles. The B horizon generally has its maximum clay at a depth of 20 to 30 inches, but maximum clay may be as deep as 40 inches.

Vesser soils have a much thicker grayish subsurface layer than Humeston and Tuskeego soils and less clay in the subsoil. The colors in the upper part of the subsoil of Vesser soils are lighter than those in the Humeston soils. The depth to maximum content of clay is greater in Vesser than in Humeston or Tuskeego soils. Vesser soils differ from Amana soils in having a thick grayish subsurface layer with a distinct clay increase from the subsurface layer to the subsoil. Also, Vesser soils have a more developed and more clayey subsoil than Amana soils.

Vesser silt loam (Ve).—This nearly level soil occurs on bottom lands and convex low stream terraces. About half of it is nearly level or slightly depressional and is ponded after heavy rains. The other half does not flood so frequently. This soil has a black or very dark brown surface layer about 10 inches thick. Where this soil is in the slightly elevated position, the very dark grayish-brown to dark grayish-brown subsurface layer is generally less visible and the subsoil has a slightly lower content of clay. Vesser silt loam is closely associated with the Amana, Che-

quest, Colo, and Wabash soils of first bottoms. Some areas are associated with Watkins and Koszta soils on stream terraces.

Included with this soil in mapping are a few areas that have a slightly thicker surface layer, lack the gray subsurface layer, and are better drained. A few areas have more clay in the subsoil and are wetter than this Vesser soil.

This soil is used intensively for row crops and is moderately well suited to corn and soybeans. Crops grow moderately well where this soil is properly drained and fertilized.

Supplemental drainage is needed. Some areas where tile outlets cannot be established require open-ditch drainage. Because of the leached grayish-brown subsurface layer, this soil generally needs large amounts of fertilizer, especially phosphorus and potassium for good plant growth. Additions of lime also are required. (Capability unit IIw-1; woodland suitability group 10)

Vesser silt loam, 2 to 5 percent slopes (VeB).—This soil is similar to Vesser silt loam, except that it is more sloping. It occurs on foot slopes along the outer edges of the larger stream bottoms. It is generally below the moderately sloping to strongly sloping, loess-derived Clinton, Ladoga, or Otley soils. Some areas are below the till-derived Adair, Keswick, Lindley, and Gara soils. It is above the Chequest, Colo, Wabash, and other soils of the first bottoms and terraces.

Included with this soil in mapping are areas that have a loam surface layer. This is the result of sediments brought in from adjacent slopes and discharged from small upland drains. These areas are generally below upland slopes of till-derived soils.

This Vesser soil is used intensively for row crops and is moderately well suited to corn and soybeans. It is friable and easily tilled. It generally is farmed with the adjacent soils on bottoms and terraces, since it occurs as narrow strips between these soils and the uplands.

This soil is wet and seepy in wet years and requires tile drainage. Also needed are diversion terraces that protect this soil against runoff from the adjacent slopes. Because of the leached gray subsurface layer, more fertilizer is generally needed for this soil than for other soils that have similar nutrient levels. Additions of lime also are needed. (Capability unit IIw-3; woodland suitability group 10)

Wabash Series

The Wabash series consists of very poorly drained soils that developed from clayey alluvium under prairie grasses and sedges tolerant of excess wetness. They are on first bottoms along the major streams of the county. Slopes are less than 1 percent. Individual areas are on the lowest elevations within the bottom lands and generally lie some distance from the major stream channel.

In a typical profile the surface layer is about 15 inches thick. It is very dark gray and black silty clay loam in the upper 11 inches and black silty clay in the lower part. The lower part has a few yellowish-brown and strong-brown mottles. The subsoil, which extends to a depth of 57 inches, is very dark gray, dark-gray, and gray silty clay that grades to silty clay loam below a depth of 37 inches. It is mottled with brownish and grayish colors throughout.

Wabash soils are very slowly permeable and have a high available moisture holding capacity. The surface layer is typically medium acid to slightly acid, and the subsoil is slightly acid but grades to neutral as depth increases. These soils are medium in available nitrogen, medium to high in available phosphorus, and very low in available potassium.

Typical profile of Wabash silty clay loam, 1,800 feet south and 1,860 feet west of the northeast corner section 23, T. 75 N., R. 11 W., on a level flood plain:

Ap—0 to 6 inches, very dark gray (10YR 3/1) silty clay loam; weak, fine, subangular blocky and granular structure; firm; few, fine, soft concretions of a dark-brown oxide; medium acid; abrupt, smooth boundary.

A1—6 to 11 inches, black (10YR 2/1) silty clay loam; moderate, very fine, subangular blocky structure; firm; few, fine, soft concretions of a dark-brown oxide; slightly acid; clear, smooth boundary.

A3—11 to 15 inches, black (10YR 2/1) light silty clay; few, fine, distinct mottles of yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6); moderate, fine, prismatic structure that breaks to strong, very fine, subangular blocky structure; firm; distinct sheen on ped surfaces; few, fine, soft concretions of a dark-brown oxide and few, fine, moderately hard concretions of a black oxide; slightly acid; clear, smooth boundary.

B1—15 to 18 inches, very dark gray (10YR 3/1) silty clay; few, fine, distinct mottles of dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6); moderate, fine, prismatic structure that breaks to strong, very fine, subangular blocky structure; very firm; distinct sheen on ped surfaces; few, fine, soft concretions of a strong-brown oxide; slightly acid; clear, smooth boundary.

B21—18 to 30 inches, very dark gray (10YR 3/1) silty clay; few, fine, distinct mottles of strong brown (7.5YR 5/6) and grayish brown (2.5Y 5/2); moderate, fine, prismatic structure that breaks to moderate, very fine, subangular blocky structure; very firm; distinct sheen on ped surfaces; few, fine, moderately hard concretions of a strong-brown oxide; slightly acid; clear, smooth boundary.

B22g—30 to 37 inches, very dark gray (N 3/0) and dark-gray (5Y 4/1) silty clay; common, fine, prominent mottles of yellowish brown (10YR 5/6) and a few, medium, faint mottles of light gray (5Y 6/1) and light olive gray (5Y 6/2); moderate, fine, prismatic structure that breaks to moderate, fine subangular blocky structure; very firm; sheen on some ped surfaces; few clay fills in root channels; few, fine, moderately hard concretions of black and strong-brown oxides; very dark gray (5Y 3/1) krotovina that is 2 inches in diameter; slightly acid; gradual, smooth boundary.

B3g—37 to 57 inches, dark-gray (5Y 4/1) and gray (5Y 5/1) silty clay grading to heavy silty clay loam in the lower part; common, fine, prominent mottles of yellowish brown (10YR 5/6, 5/8) and very few, very fine, prominent mottles of strong brown (7.5YR 5/6); moderate, medium, prismatic structure that breaks to moderate, medium, subangular blocky structure; very firm; few, fine, moderately hard concretions of a black oxide and very few, fine, moderately hard concretions of a strong-brown oxide; neutral; gradual, smooth boundary.

The A horizon ranges from black to very dark gray in color and from silty clay loam to silty clay in texture. Dark colors are present to a depth of 36 inches and more in places. In places the A horizon is buried by 6 to 20 inches of recent overwash. The B horizon ranges from very dark gray to gray or light olive gray and is distinctly gleyed. Shiny ped surfaces are common, and some may be clay. The B horizon ranges from 48 to 58 percent in content of clay. Yellowish-brown

and strong-brown mottles occur throughout the B horizon and tend to increase as depth increases. The solum is slightly acid in the most acid part. The upper part of the substratum, like the lower subsoil, is gray to light gray, very fine and firm silty clay or heavy silty clay loam.

Wabash soils have more clay in the subsoil than Chequest soils and are thicker and darker colored in the upper part of the subsoil. Also, they are less mottled in the subsoil and less acid than the Chequest soils. Wabash soils have a higher content of clay in the subsoil than Zook and Colo soils.

Wabash silt loam, overwash (Wa).—This soil has a very dark gray to grayish-brown layer of overwash 6 to 20 inches thick. Below this the profile is similar to the one described as typical for the series.

This soil formed from fine-textured alluvium on the first bottoms of major streams. It is generally adjacent to or near the uplands in close association with Zook, Chequest, Colo, and Radford soils of the first bottoms. Included with this soil in mapping are areas where the overwash layer is silty clay loam.

Most of Wabash silt loam, overwash, is used for row crops. Corn and soybeans are grown, but soybeans generally do better than corn. This soil is low to medium in fertility. The lighter colored overwash material is more friable and easier to work than the original surface layer.

This soil is subject to severe wetness. The subsoil is very fine textured, and the soil may be flooded by adjacent streams or by runoff from uplands. Some areas are slightly depressional and are ponded. Dikes, diversion terraces, and open ditches are used to prevent flooding and to improve drainage. Tile drains are not recommended, but surface drains remove ponded water and lower the water table slightly. (Capability unit IIIw-1; woodland suitability group 10)

Wabash silty clay loam (Wc).—This soil has a black to very dark gray surface layer 6 to 15 inches thick. The subsoil is generally black to dark-gray silty clay that has common strong-brown mottles to a depth of about 30 to 35 inches. The lower part of the subsoil is gray to olive-gray silty clay.

This soil formed from fine-textured alluvium on the first bottoms of major streams. It is generally near or adjacent to the uplands in close association with the Zook, Chequest, and Colo soils.

Included with this soil in mapping are a few areas where the gray or olive-gray subsoil is within 20 inches of the surface. These included soils typically are medium acid to strongly acid. Also included are areas where the surface layer is silty clay.

Most of this Wabash soil is used for row crops. It is better suited to soybeans than to corn. Crops do not grow well on this soil.

The hazard of wetness is severe in this soil, and a few areas are slightly depressional and pond water. This soil often receives runoff from the adjacent uplands and adjacent streams. Drainage can be improved by using open ditches, diversion terraces in the uplands, and dikes to prevent flooding from the streams. Since most areas of this soil are relatively small, it is often tiled with the adjacent soils. Because of the high clay content, however, tile functions poorly in this soil and is unsatisfactory in many places. The surface layer is firm, sticky, and difficult to work when wet, and it becomes hard and cloddy when dry. (Capability unit IIIw-1; woodland suitability group 10)

Watkins Series

The Watkins series consists of moderately well drained silty soils that developed from alluvium of low sand content under a native vegetation of prairie grasses and trees. These soils are on low stream benches throughout the county. They occur with the Tuskeego and Koszta soils.

In a typical profile the surface layer is very dark gray silt loam about 8 inches thick. The subsurface layer, about 4 inches thick, is very dark grayish-brown and dark grayish-brown silt loam. The subsoil, which extends to a depth of 60 inches, is friable to firm, light to medium silty clay loam that ranges from dark grayish brown and dark brown to brown, yellowish brown, and grayish brown.

Watkins soils are moderately permeable and have a high available moisture holding capacity. The surface layer and subsoil are mostly medium acid in reaction, but the lower subsoil and substratum are slightly acid and neutral. These soils are low in available nitrogen, low to medium in available phosphorus, and very low in available potassium.

Typical profile of Watkins silt loam, 270 feet west and 400 feet south of the northeast corner of the NW¼ section 22, T. 77 N., R. 12 W.:

Ap—0 to 8 inches, very dark gray (10YR 3/1) medium silt loam, very dark gray (10YR 3/1) when kneaded; cloddy to weak, fine, granular structure; friable; strongly acid; abrupt, smooth boundary.

A2—8 to 12 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) heavy silt loam, dark grayish brown (10YR 4/2) when kneaded; weak, medium, platy structure; friable; medium acid; clear, smooth boundary.

B1—12 to 18 inches, dark grayish-brown (10YR 4/2) and dark-brown (10YR 4/3) light to medium silty clay loam; moderate, fine, subangular blocky structure; friable; discontinuous, thin, light-gray (10YR 7/1, dry), grainy ped coats; medium acid; clear, smooth boundary.

B21t—18 to 24 inches, medium silty clay loam that has brown (10YR 5/3) ped exteriors and yellowish-brown (10YR 5/4) ped interiors; moderate, fine, subangular blocky structure; friable; few, thin, patchy clay films; thin, discontinuous, grainy ped coats that are light gray (10YR 7/1) when dry; medium acid; clear, smooth boundary.

B22t—24 to 41 inches, brown (10YR 5/3) and yellowish-brown (10YR 5/4) silty clay loam; few, fine, distinct mottles of strong brown (7.5YR 5/6) and few, fine, faint mottles of grayish brown (2.5Y 5/2); weak, medium, prismatic structure that breaks to moderate, fine, subangular blocky structure; firm; few, thin, patchy clay films; thin, discontinuous, grainy ped coats that are light gray (10YR 7/1) when dry; medium acid; clear, smooth boundary.

B3—41 to 60 inches, brown (10YR 5/3) and grayish-brown (2.5Y 5/2) light silty clay loam; moderate, medium, prismatic structure; friable; few, fine, soft concretions of a black oxide; common strong-brown (7.5YR 5/6) oxide segregations that are 1 to 3 millimeters in diameter; very distinct, continuous, grainy ped coats that are light gray (10YR 7/1) when dry; neutral; gradual boundary.

The Ap horizon ranges from 6 to 9 inches in thickness and from very dark brown and very dark gray to very dark grayish brown in color. The A2 horizon is dark grayish-brown silt loam 4 to 8 inches thick. The B horizon is a silty clay loam and is dark brown to yellowish brown in the upper part and grayish brown in the lower part. In some places sand grains occur in the lower part of the solum, but the sandy material is generally below a depth of 40 inches. The

maximum clay content in the B2 horizon generally ranges from 30 to 35 percent, but some thin horizons are as much as 38 percent clay. The lower part of the subsoil and the substratum are brown and dark grayish-brown, friable to firm silty clay loam. In places the substratum is stratified with thin lenses of sand and has strong-brown mottles. The solum is medium acid to strongly acid in the most acid part.

Watkins soils have browner colors in the upper part of the subsoil than Koszta soils. They have a lower clay content in the subsoil than Ladoga soils and may be stratified below a depth of 40 inches.

Watkins silt loam, 0 to 2 percent slopes (WkA).—This soil has a very dark brown surface layer about 8 inches thick. The dark colors may extend to a depth of more than 12 inches in places.

This soil is on low stream terraces, slightly above the flood plains of rivers and larger streams. It occurs closely with Koszta and Chequest soils and is slightly higher on the landscape. In some areas it is completely surrounded by Amana, Colo, and other soils of the first bottoms.

Included with this soil in mapping are small areas that have a lighter colored surface layer. In some areas the dark surface layer extends to a depth of as much as 24 inches.

This soil is moderately high in organic-matter content and is generally in good tilth. It warms quickly in spring. When rainfall is above average, some areas are flooded occasionally. Sandy strata may occur at depths of 48 to 60 inches and as shallow as 40 inches in places, but crops are generally not damaged by lack of moisture.

Individual areas of this Watkins soil are commonly 3 to 14 acres in size. Nearly all of this soil is cultivated. It is fertile and suited to intensive row cropping. Where it is used intensively for row crops, this soil requires good management of crop residue and regular applications of fertilizer. This soil is acid unless recently limed. (Capability unit I–1; woodland suitability group 1)

Watkins silt loam, 2 to 5 percent slopes (WkB).—This soil is similar to Watkins silt loam, 0 to 2 percent slopes, except that it has a very dark gray and very dark grayish-brown surface layer 6 to 9 inches thick. It occurs on gently sloping low stream terraces. The erosion hazard is slight. This soil occurs closely with Koszta and Chequest soils and is higher on the landscape. In some areas it is completely surrounded by Colo, Amana, or other soils of the first bottoms.

Included with this soil in mapping are a few small areas that have a lighter colored and thinner surface layer and some areas where the dark colors extend to a depth of as much as 18 inches. Also included are a few small areas that have a loam surface layer and small areas that have slopes of more than 5 percent.

This soil is well suited to row crops. Individual areas are commonly 3 to 14 acres in size and nearly all of it is cultivated. This soil warms quickly in spring, and crops grow well under good management.

Contour tillage helps to reduce the slight erosion hazard, but many areas are difficult to till on the contour and to terrace because slopes are irregular. Sandy strata occur at depths of 48 to 60 inches and even as shallow as 40 inches in places, but crops are generally not damaged by lack of moisture. This soil is acid unless recently limed. (Capability unit IIe–1; woodland suitability group 1)

Zook Series

The Zook series consists of poorly drained soils that developed from clayey alluvium that contains little sand. The native vegetation was prairie grasses and sedges tolerant of excess wetness. These soils are on first bottoms and have slopes of less than 1 percent.

In a typical profile the surface layer is black, firm silty clay loam about 21 inches thick. The subsoil, which extends to a depth of 55 inches, is black, firm light silty clay in the upper 24 inches and black silty clay loam in the lower part. Olive-gray mottles occur below a depth of about 28 inches and increase in numbers as depth increases.

Zook soils are very slowly permeable and have a high available moisture holding capacity. The surface layer ranges from neutral to medium acid, and the subsoil is slightly acid but may grade to neutral as depth increases. These soils are medium in available nitrogen, low in available phosphorus, and very low in available potassium.

Typical profile of Zook silty clay loam, 2,580 feet east and 190 feet south of the northwest corner of the NW¼ section 23, T. 75 N., R. 11 W., on a level flood plain:

Ap—0 to 6 inches, black (10YR 2/1) light silty clay loam; weak, fine, granular and fine, subangular blocky structure; firm; neutral; abrupt, smooth boundary.

A1—6 to 15 inches, black (10YR 2/1) medium silty clay loam; weak, fine, subangular blocky and granular structure; firm; few, fine, soft concretions of a dark-brown oxide; slightly acid; gradual, smooth boundary.

A3—15 to 21 inches, black (10YR 2/1) heavy silty clay loam; few, fine, faint mottles of dark grayish brown (10YR 3/2); moderate, very fine, subangular blocky structure; firm; few, fine, soft concretions of a dark-brown oxide; slightly acid; gradual, smooth boundary.

B1—21 to 28 inches, black (10YR 2/1) light silty clay; weak, medium, prismatic structure that breaks to moderate, very fine, subangular blocky structure; firm; sheen on ped faces; few, fine, soft concretions of a brown oxide and few, fine, hard concretions of a black oxide; slightly acid; gradual boundary.

B2—28 to 45 inches, black (10YR 2/1) light silty clay; common, fine, distinct mottles of olive gray (5Y 4/0) in the lower part; moderate, fine, prismatic structure that breaks to moderate, fine, subangular blocky structure; firm; prism faces are smooth and shiny when moist; very few, fine, soft concretions of a strong-brown oxide and very few, fine, hard concretions of a black oxide; slightly acid; gradual, smooth boundary.

B3g—45 to 55 inches, black (N 2/0) heavy silty clay loam; common, fine, distinct mottles of olive gray (5Y 4/2) and few, fine, distinct mottles of olive (5Y 4/3) that increase to common below a depth of 52 inches; weak, fine to medium, prismatic structure; firm; prism faces are smooth and shiny when moist; very few, fine, soft concretions of a strong-brown oxide and very few, fine, hard concretions of a black oxide; slightly acid.

The A horizon is black or very dark gray silty clay loam 15 to 24 inches thick. In some places this layer is buried by 20 inches of stratified light-colored sediment. The B horizon ranges from heavy silty clay loam to silty clay that is about 38 to 46 percent clay. The B horizon ranges from very dark gray to dark gray and olive gray below a depth of 40 inches and is mottled with olive gray and strong brown. Dark colors extend to a depth of 36 inches or more. The solum is slightly acid in the most acid part.

Zook soils have a more clayey subsoil than Colo soils but have less clay in the subsoil and substratum than Wabash

soils. Zook soils are less acid than Chequest soils, have a less strongly developed subsoil, and are deeper to gray or dark-gray colors.

Zook silt loam, overwash (Zk).—This soil has very dark gray to grayish-brown stratified silt loam overwash 6 to 20 inches thick. Below this is a black silty clay loam similar to the surface layer of the profile described as typical for the series.

This soil is on nearly level bottoms of major streams throughout the county. It is closely associated with the Chequest and Wabash soils. Many areas are adjacent to foot slopes onto which small upland drainageways have emptied and deposited the stratified surface layer. In other areas sediment in the surface layer was deposited by flood waters.

Included with this soil in mapping are areas that have a silty clay loam overwash.

This soil is used intensively for row crops. Where adequate drainage is provided, this soil is suitable for corn and soybeans. Because of the stratified silty overwash, the surface layer is friable and in good tilth.

The dark-colored lower horizons are very slowly permeable. Tile drains function where tile lines are closely spaced and outlets are available. Some areas need shallow ditches for supplemental surface drainage. Fieldwork is sometimes delayed on this soil by excessive wetness and flooding. Crops mature slowly and harvests are sometimes delayed. Small additions of lime are required. (Capability unit IIIw-1; woodland suitability group 10)

Zook silty clay loam (Zo).—This soil has a black surface layer 15 to 24 inches thick. The subsoil is black light silty clay loam that generally extends to depths of 40 inches or more. This soil occurs on the nearly level bottoms of major streams throughout the county. Many areas adjacent to foot slopes are closely associated with the Chequest and Wabash soils. In some areas water is ponded after heavy rains. Included with this soil in mapping are a few areas that have a silty clay surface layer.

This soil is used intensively for row crops. Where drainage is adequate, this soil is suited to corn and soybeans. Commonly the soil dries out and warms slowly in spring. Crops often mature slowly, and harvests are sometimes delayed.

Fieldwork is often delayed because of excess wetness and flooding. Tile drains function where close spacing and adequate outlets are available. Some areas require shallow surface drains. The black surface layer is high in organic-matter content but is generally in poor tilth. Seedbeds are difficult to prepare because the soil puddles easily and dries out hard and cloddy. This soil may require small additions of lime for good plant growth. (Capability unit IIIw-1; woodland suitability group 10)

Use and Management of the Soils

The soils of Keokuk County are used mostly for crops and pasture. Corn and soybeans are the main crops. The trees in the county grow mostly along streams, or they are planted in windbreaks. This section tells how the soils are used for these purposes and also for building roads, farm ponds, and other engineering structures.

Use of the Soils for Crops and Pasture

In this subsection the effect of soil properties on the growth of crops is first discussed. Then the system of capability grouping used by the Soil Conservation Service is explained, the groups of soils are described, and use and management of them are discussed. A table lists predicted yields of the principal crops grown in the county at two levels of management.

Effect of soil properties on growth of crops

Farmers must know their soils if they are to make a successful plan for controlling erosion, improving the soil, selecting crops, and maintaining good yields. The suitability of a soil for certain plants and the management needed depends on drainage, permeability, texture, slope, content of organic matter, and other characteristics given in the soil descriptions.

Drainage is generally indicated by the color and mottling of the subsoil. The subsoil of the Taintor soils is dominantly gray, indicating poor drainage, and the subsoil of the Clinton soils is brownish, indicating moderately good drainage. Besides knowing the drainage class, it is important to know how often and for how long the soil is saturated, the permeability of the major horizons, and the capacity of the soil to hold water available to plants.

Permeability is the ability of soil to transmit air and water. Fine-textured, compact soils generally have slow permeability and absorb moisture slowly. The Wabash and Clarinda soils are of this kind. Water ponds on the surface or it runs off rapidly, depending on slope. This runoff causes erosion, especially if the soil is cultivated. Where artificial drainage is needed, farmers should know the permeability of the soils before deciding what kind of drainage system to install.

Texture is the proportion of sand, silt, and clay in a soil. It affects the amount of water the soil can hold, its permeability, and the ease or difficulty with which it can be cultivated and penetrated by plant roots. Texture is considered in determining the kind of drainage system to install and the choice of crops. Fine textured soils, such as those in the Wabash and Clarinda series, do not absorb moisture rapidly and are difficult to work. Coarse soils, such as the Sparta, do not hold much water available for plants. The Otley, Judson, Olmitz, and similar soils have textures favorable for plant growth. The proportion of sand, silt, and clay is such that available water capacity is good and the soils are not difficult to work.

Slope affects runoff and determines the need for controlling erosion. The rate of runoff and hazard of erosion increase as the degree of slope increases. On slopes of more than 2 percent, the soils are subject to erosion where cultivated. Erosion losses are greater where there is no plant cover. Gara loam, 14 to 18 percent slopes, moderately eroded, is an example of a soil that has been eroded because of its strong slopes and rapid runoff. Steep slopes limit the use of farm machinery and generally have thinner stands of row crops than more nearly level slopes.

An *adequate supply of plant nutrients* must be available. Crops on most of the soils in the county respond to applications of fertilizer. The need for fertilizer depends on the kind of soil, past and present management, and

the crop that is grown. Additions of lime are generally needed on most soils unless they have been limed within the past 5 years. A few soils, such as the Zook and Wabash, generally do not need lime. For best results, the amount of lime and the kinds and amounts of fertilizers can best be determined by soil tests.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or for engineering.

In the capability system, all kinds of soils are grouped at three levels—the capability class, subclass, and unit. These are discussed in the following paragraphs.

Capability Classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

- Class I soils have few limitations that restrict their use.
- Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.
- Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.
- Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.
- Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife.
- Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife.
- Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife.
- Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes. (None in Keokuk County)

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion, unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-2 or IIIs-1. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

In the following pages the capability units in Keokuk County are described and suggestions for the use and management of the soils are given. The mention of the soil series represented in each capability unit does not mean that all the soils in the series are in the unit. To determine the soils in a capability unit, refer to the "Guide to Mapping Units" at the back of this survey.

CAPABILITY UNIT I-1

This unit consists of deep, nearly level soils of the Givin, Keomah, Koszta, Mahaska, and Watkins series. These soils occur in the uplands and on stream benches. They have a friable, medium-textured surface layer and a friable or firm, medium-textured or moderately fine textured subsoil. Permeability is moderate or moderately slow.

These soils are easily tilled and are readily penetrated by roots to a depth of several feet. The Mahaska soils are slightly finer textured in the surface layer than the other soils in this unit and are more suitable for fall plowing. Erosion caused by runoff is not a hazard on any of these soils.

The Mahaska soils contain more organic matter than the other soils in this unit, and the Keomah soils contain the least. All of the soils have a high available moisture holding capacity. Drainage generally is adequate in most years, but in wet years tile drains are beneficial and permit more timely field operations, particularly early in spring. The Koszta soils are susceptible to occasional flooding early in spring, or in periods when rainfall is unusually high, but flooding in spring usually occurs before crops are planted.

The soils in this unit are well suited to corn and soybeans. If row crops are grown for several successive

years on Keomah soils, tillage needs to be kept to a minimum so as to prevent the soils from compacting. This is because Keomah soils contain so little organic matter. On the soils of this unit insects, weeds, and plant diseases are more difficult to control in fields where corn is grown continuously. Soybeans commonly are substituted for corn in the rotation. Soils that are heavily cropped and that are plowed to the same depth for successive years tend to develop a plowpan or compact layer at plow depth. This layer restricts the movement of air and water. Changing the depth of plowing helps to prevent the formation of a pan.

CAPABILITY UNIT I-2

In this unit are nearly level Amana, Nodaway, and Radford soils. These soils occur on flood plains and are subject to flooding. They are moderately well drained or somewhat poorly drained, and except in wet years, they can be cropped without supplemental drainage. The use of dikes to protect these soils from flooding may be feasible, but floods ordinarily occur early in spring before corn is planted and last only a short time.

The soils in this unit can be used intensively for corn and soybeans. Some areas are in pasture. Although corn is the more important crop, soybeans are commonly substituted for it, particularly if the planting of corn would be delayed by flooding. Planting corn year after year increases the hazards of plant diseases and insect damage. Controlling weeds is especially important because floodwaters commonly deposit the seeds of these undesirable plants. Partly because the soils in this unit are not subject to erosion, they are often plowed in fall so that planting can be earlier in spring.

CAPABILITY UNIT IIe-1

This unit consists of gently sloping Ladoga, Otley, Watkins, Clinton, Nira, Givin, and Mahaska soils. These soils range from dark colored to light colored and, except for the somewhat poorly drained Givin and Mahaska soils, are moderately well drained. The soils in this unit have a friable, medium-textured surface layer and a friable or firm, medium-textured or moderately fine textured subsoil. Runoff is sufficient to cause some soil erosion. These soils generally occur in the uplands adjoining the broad, nearly level upland divides. Exceptions are the Watkins soils on stream benches above the flood plain and some areas of Ladoga soils on high stream benches much above the flood plain.

Except for the Clinton soils, which contain little organic matter, the soils in this unit are medium or high in organic-matter content. They absorb much of the rain that falls, but some runoff occurs because of slope. Except in the moderately permeable Watkins soils, permeability is moderately slow. Available moisture holding capacity is high.

The soils of this unit are well suited to all crops commonly grown in the county. Row crops can be grown much of the time if these soils are protected from erosion. In terraced areas, corn can be grown intensively without excessive loss of soil. Soybeans often are substituted for corn. Because the Clinton soils are low in organic-matter content, it is important to return all crop residue to the soil.

CAPABILITY UNIT IIe-2

This unit consists of moderately well drained and somewhat poorly drained, gently sloping Ely, Judson, Martinsburg, and Olmitz soils. These soils occur along upland drainageways and on foot slopes below steeper upland soils. They have a medium-textured, friable surface layer and subsoil. The content of organic matter is high in the Ely, Judson, and Olmitz soils and low in the Martinsburg soil. The soils in this unit are moderately permeable and have a high available moisture holding capacity. Except on the Ely soil, drainage normally is adequate. The Ely soil is seasonally wet and benefits from tile drainage.

Because the soils of this unit are at the base of upland slopes, runoff, which does not last long, is likely to damage the soils through sheet erosion and gullying. These soils are protected from runoff, and wetness is reduced by placing diversion terraces at the base of upland slopes.

Where they are protected from erosion, the soils in this unit can be cropped intensively to corn and soybeans. All areas, however, are not large enough to crop separately, and the cropping system may be determined by the surrounding soils. Crops respond well to applications of fertilizer.

CAPABILITY UNIT IIw-1

In this unit are poorly drained and somewhat poorly drained, dark-colored soils of the Chequest, Colo, and Vesser series. These soils occur along the major streams throughout the county and on alluvial fans below the uplands. The Colo and Chequest soils are poorly drained, moderately fine textured or medium textured, and have moderately slow permeability. The Vesser soils are medium textured and somewhat poorly drained. The soils of this unit are high in organic-matter content and have a high available moisture holding capacity.

These soils have a seasonally high water table and are subject to flooding. Flooding commonly occurs early in spring and lasts for only short periods. Recent floodwaters have deposited a lighter colored and coarser textured material on some areas of the Colo and Chequest soils. In some places siltation is a hazard if heavy rains occur when crops are small and adjoining higher soils have not been protected from erosion.

The soils of this unit are well suited to row crops but require artificial drainage for best crop growth. They can be successfully drained with tile if suitable outlets are available (fig. 10). In depressional areas that collect surface water, surface drainage is needed in addition to the tile.

Where adequately drained and well managed, these soils can be used intensively for row crops. Corn is the most important row crop, but soybeans are often substituted for it. These soils are often plowed in fall. Crops generally can be planted earlier in spring if plowing is during the previous fall when moisture content is more favorable.

CAPABILITY UNIT IIw-2

The poorly drained, nearly level Taintor soils are the only soils in this unit. These soils occur on the broad upland flats and on nearly level stream benches that are high above the modern flood plain. They have a firm surface layer that is high in organic-matter content and a slowly permeable, fine-textured subsoil. Surface runoff is slow, and in places water ponds after heavy rains.

Figure 10.—**Installing tile in Chequest soils.**

These soils are slow to dry out in spring, and they puddle readily if worked when wet. Tile drainage is satisfactory where the spacing and depth of the tile are suitable. In drained areas, field operations can be much more timely. Because the water table is at or near the surface in spring and then recedes, plowing often is in fall to insure earlier planting in spring.

These soils can be used intensively for corn. There is no hazard of erosion, and soil blowing is not serious.

CAPABILITY UNIT IIw-3

This unit consists of gently sloping Colo, Ely, Martinsburg, Nodaway, Radford, and Vesser soils. These soils generally occur along the upland narrow drainageways and on alluvial fans at the mouths of the drainageways (fig. 11, top). In some places the Colo and Vesser soils are gently sloping on foot slopes below the uplands. The soils in this unit are moderately well drained, somewhat poorly drained, and poorly drained. Except for the Colo soils, they have a friable, medium-textured surface layer and subsoil. The Colo soils are moderately fine textured and have a moderately slow permeability.

The soils of this unit are wet mainly because of a seasonally high water table and seepage from the higher soils on uplands. Flooding by runoff is common for short periods, and gullying is likely where runoff water concentrates. Siltation also is a hazard if heavy rains occur when crops are small and adjoining higher soils are not protected from erosion.

Permanent grassed waterways are needed on these soils where the water concentrates and gullies tend to form (fig. 11, middle). In some places additional erosion-control structures are needed to prevent gullies from forming at tile outlets. Tile lines are beneficial if they are properly installed. A tile line is commonly needed on each side of the watercourse to lower the water table and to control seepage (fig. 11, bottom).

Although these soils are well suited to row crops, areas are small or of odd shape in some places, and the cropping system is determined by the surrounding soils. In

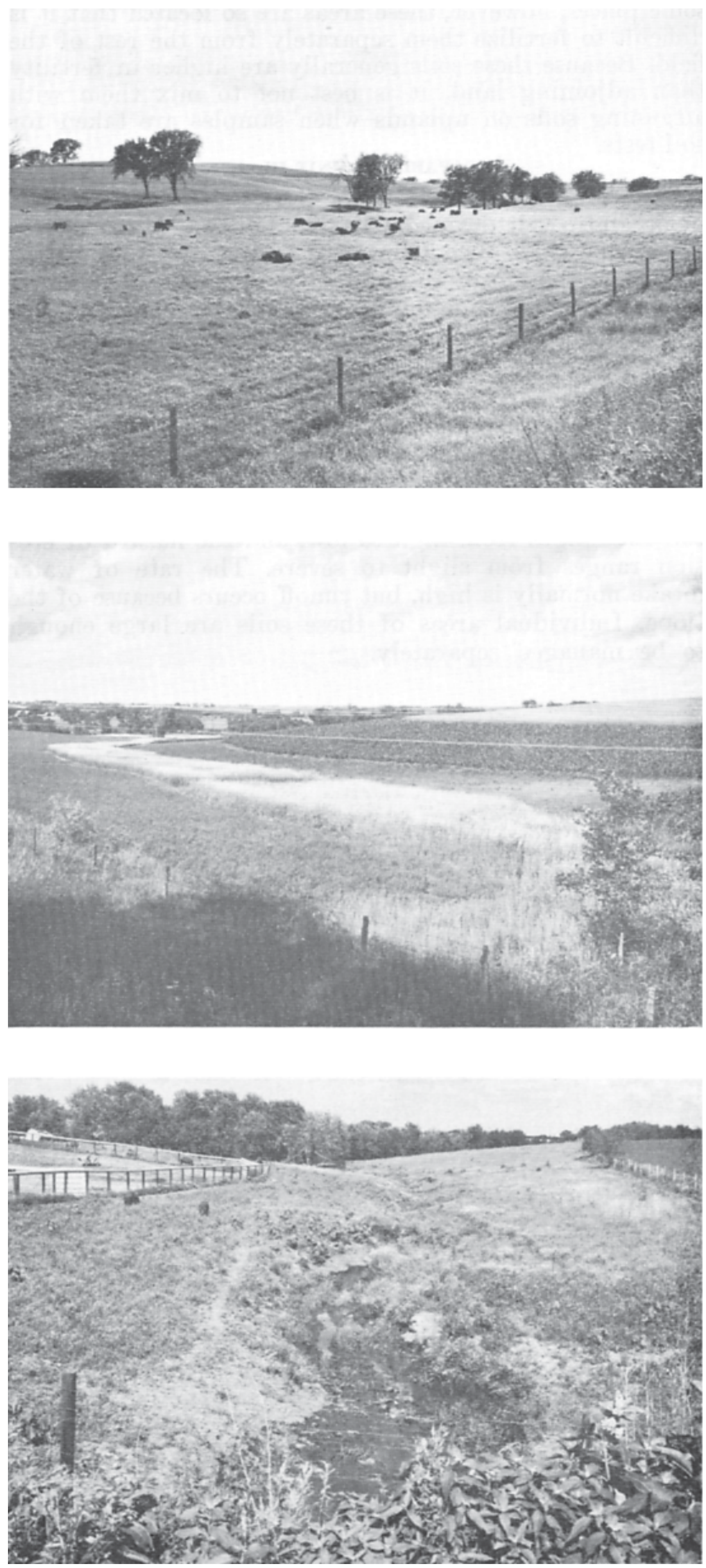

Figure 11.—**Colo-Ely silty clay loams, 2 to 5 percent slopes. Top, an improved pasture on a typical alluvial fan. Middle, a well-established grassed waterway in a contoured, stripcropped area. Bottom, an area needing tile lines to control seepage.**

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some places, however, these areas are so located that it is difficult to fertilize them separately from the rest of the field. Because these soils generally are higher in fertility than adjoining land, it is best not to mix them with adjoining soils on uplands when samples are taken for soil tests.

CAPABILITY UNIT IIIe-1

This unit consists of deep, dark- and light-colored, moderately well drained Clinton, Ladoga, Martinsburg, and Otley soils. The Clinton, Ladoga, and Otley soils have a friable, medium-textured or moderately fine textured surface layer and a firm, moderately fine textured subsoil that is moderately slow in permeability. Slopes range from 5 to 14 percent. These soils occur in sloping, dissected uplands throughout the county. The Martinsburg soil has a friable, medium-textured subsoil that is moderately permeable. It occurs on foot slopes below the steeper Clinton soils. All the soils of this unit have a high available moisture holding capacity. The organic-matter content ranges from high to low, and the hazard of erosion ranges from slight to severe. The rate of water intake normally is high, but runoff occurs because of the slope. Individual areas of these soils are large enough to be managed separately.

The soils of this unit are well suited to most crops grown in the county. Corn is the most common row crop, but soybeans are sometimes substituted for corn in the cropping system.

Contour plowing, terracing, and stripcropping are used to help control erosion in cultivated fields (fig. 12). Terracing is more permanent than tilling on the contour, and the soils of this unit are better suited to terracing than are the other soils in the county. Where they are terraced, these soils frequently can be cropped to corn and soybeans without excess loss of soil, water, or applied fertilizers. Because the severely eroded Clinton and Ladoga soils are low in organic-matter content, they may need more meadow crops than the other soils to maintain suitable tilth.

CAPABILITY UNIT IIIe-2

This unit consists of the somewhat poorly drained Adair and Lamoni soils and the poorly drained Clarinda soils. These soils are sloping and slowly permeable. They have a friable or firm, moderately fine textured surface layer and a very firm clayey subsoil that restricts the downward movement of water. These soils are seasonally wet because water seeps from the more permeable soils upslope. Runoff is fairly rapid, and erosion is difficult to control.

Figure 12.—Stripcropping and a grassed waterway in Clinton soils in capability unit IIIe-1.

These soils commonly occur in narrow bands, almost in a pattern of contours. They are closely associated with the Otley soils upslope and with the Shelby soils downslope and, in most places, are cropped the same way as are those soils.

The soils of this unit puddle easily if they are worked when wet, and they dry out cloddy and hard. In spring tractors commonly are mired in these wet areas. Interceptor tile drains are needed in some seepy areas.

These soils are not well suited to row crops. Where row crops are planted, the soil should be tilled on the contour. These soils are not suited to terracing, because cuts expose the heavy compacted, infertile subsoil. Although the response to fertilizer is fairly good, crops normally do not grow well. Many areas are left in meadow for an extra year or more when the surrounding soils are cultivated.

CAPABILITY UNIT IIIw-1

This unit consists of the very poorly drained Wabash soils and the poorly drained Zook soils. These soils occur on bottom lands and are nearly level or slightly depressional. They have a black, plastic surface layer that generally is silty clay loam. Their subsoil is very slowly permeable, plastic silty clay. Some areas are covered with 6 to 20 inches of recent overwash consisting of stratified silt loam. The water table is seasonally at or near the surface. The rate of water intake is slow, the movement of water through the plastic subsoil is very slow, and the available water holding capacity is high.

These soils warm slowly in spring, and they cannot be worked early in spring or soon after rains. They puddle readily if worked when wet, and they dry out hard and cloddy. If these soils are plowed in fall, freezing and thawing during winter improve tilth. The soils that have a silt loam overwash have better tilth than the other soils, and they can be worked throughout a wider range of moisture content.

Properly spaced tile lines lower the water table in the Zook soils, but tile generally does not drain the Wabash soils satisfactorily. Shallow surface drains are helpful in removing surface water. Although the use of these soils is limited because of wetness and flooding, improved areas are used for cultivated crops. Flooding often occurs early in spring before crops are planted, but in some years damage to crops is extensive. In years that have above average rainfall, many areas are left idle because crops cannot be planted or they are drowned out. Corn is the principal row crop, but soybeans also are grown.

CAPABILITY UNIT IIIw-2

This unit consists of moderately dark colored and dark colored Humeston, Rubio, Sperry, and Tuskeego soils. These soils occur on uplands and bottom lands. They normally are in slightly depressional areas and are often ponded during extended wet periods or after heavy rains. They have a friable silt loam surface layer, a grayish silt loam subsurface layer, and a firm, fine-textured, slowly permeable subsoil. The Humeston soils are occasionally flooded. Tile lines do not drain all areas satisfactorily, and surface drains are needed.

Corn and soybeans are the principal crops, but the cropping system generally is determined by the way surrounding soils are used. In many places, the soils of this unit occur in small areas and in wet years may be left idle when surrounding soils are cultivated. Alfalfa and other legumes frequently are drowned or winterkilled. Crop response to fertilizer varies, but it is good in years of average rainfall and in adequately drained areas.

Although the soils in this unit need fertilizer, they generally are in areas of such size and shape that they are fertilized in the same way as are larger areas of surrounding soils. Consequently, care should be taken to avoid the soils in this unit if samples for soil tests are required for the surrounding soils. For the soils in this unit, tests are needed only for areas large enough to fertilize separately.

CAPABILITY UNIT IIIs-1

In this unit are the gently sloping and sloping, well-drained to excessively drained Chelsea, Clinton, Dickinson, Ladoga, Lamont, and Sparta soils. Mapped together because they are so closely associated are the Dickinson, Ladoga, and Sparta soils and the Clinton, Chelsea, and Lamont soils.

The Clinton and Ladoga soils have a medium-textured surface layer and a moderately fine textured subsoil. The Lamont and Dickinson soils are moderately coarse textured, and the Sparta and Chelsea soils are coarse textured. The Chelsea, Dickinson, Lamont, and Sparta soils have a low or very low moisture holding capacity and are rapidly permeable. The Clinton and Ladoga soils have a high available water holding capacity and moderately slow permeability.

The soils of this unit are quick to warm up in spring, and they can be worked soon after rains. These soils are susceptible to water erosion. Where they are left unprotected, the sandier soils are susceptible to both water erosion and soil blowing, particularly in spring. In most areas, management is difficult because slopes are complex. Constructing terraces is difficult on the sandy soils, which are better suited to stripcropping for erosion control than to terracing. The soils of this unit generally need to be seeded to meadow crops to keep soil losses at an allowable level.

CAPABILITY UNIT IVe-1

This unit consists of sloping and moderately steep, moderately dark- and light-colored soils of the Chelsea, Clinton, Ladoga, Lamont, Dickinson, and Sparta series. These soils occur in the dissected uplands throughout the county.

The Dickinson, Lamont, Sparta, and Chelsea soils are moderately coarse and coarse textured. They are rapidly permeable and droughty. The Ladoga and Clinton soils have a friable, medium-textured surface layer and a subsoil that is moderately fine in texture and moderately slow in permeability. The soils of this unit have slopes ranging from 9 to 18 percent, and all areas are subject to erosion. Organic-matter content ranges from medium in less eroded areas to very low in severely eroded areas. The available water holding capacity is high in the Clinton and Ladoga soils but is low or very low in the Dickinson, Lamont, Chelsea, and Sparta soils.

Because of the strong or moderately steep slopes and erosion, the soils in this unit are not well suited to row crops. A cropping system that includes a high percent-

age of meadow crops is needed to control erosion. Because of the slopes and irregular topography, the soils in this unit are not well suited to terracing.

CAPABILITY UNIT IVe-2

This unit consists of sloping and strongly sloping, slowly and very slowly permeable Adair, Clarinda, Lamoni, and Keswick soils. These soils have a firm, moderately fine textured surface layer and a very firm, clayey, compact subsoil. They have restricted drainage because of the slow permeability and are seasonally wet and seepy. Cultivated areas are susceptible to erosion. Although most areas of these soils have been damaged by erosion, a few wooded areas of the Keswick soils have been protected by trees.

The soils in this unit commonly are in narrow bands that are almost on contours around the hillside. Many small areas are surrounded by larger areas of soils that are used for row crops, but the small areas often are left in grass when the surrounding areas are cultivated. Erosion control is difficult in areas that are cropped with the surrounding soils. Building terraces in these areas exposes the fine-textured, infertile subsoil in the terracing channels.

The soils in this unit are best suited to oats, hay, and pasture. They are not well suited to row crops. Many areas of these soils have sites suitable for farm ponds that supply water for livestock.

CAPABILITY UNIT IVe-3

This unit consists of moderately well drained, moderately eroded Gara, Lindley, and Shelby soils. These soils range from moderately dark to light colored. Some areas are gullied. The surface layer of these soils is friable and medium textured, and the subsoil is firm, moderately fine textured, and moderately slow in permeability. Slopes range from 9 to 14 percent on the Gara and Lindley soils and from 14 to 18 percent on the Shelby soils. These soils have a low to very low organic-matter content and a high available moisture holding capacity. Runoff is rapid, and erosion is a serious hazard.

These soils are not well suited to row crops. Because of past erosion, tilth is somewhat poor. Also these soils dry out hard and cloddy if they are plowed when wet. Response to fertilizer is good. Good management is needed to control erosion. Terracing is only moderately satisfactory because the topography is hilly and the subsoil is firm and moderately slow in permeability. Among the practices needed to control erosion is the growing of meadow crops much of the time. These soils provide suitable sites for farm ponds that supply water for livestock (fig. 13, top). In some areas gullies need to be shaped and seeded (fig. 13, bottom).

CAPABILITY UNIT Vw-1

This unit consists of Alluvial land and mostly silt loams of the Amana and Nodaway series. These soils are severely dissected by old stream channels and are frequently flooded. Alluvial land is sandy and excessively drained in some places and is clayey and poorly drained in others.

Except for a few isolated areas, the soils in this unit are not cultivated. Most areas are under a cover of scat-

Figure 13.—**Top, a farm pond that supplies water for livestock and also controls gullying. Gara soils are dominant. Bottom, a deep gully in class VI land. Clinton and Lindley soils are dominant.**

tered trees and grass. Cultivated fields are irregular in shape because of oxbows and old bayous. Open areas are used for pasture. Alluvial land is less desirable for pasture than the Amana and Nodaway soils because much of the vegetation is willows, shrubs, sedges, and marshgrass. On the other soils, bluegrass grows in good stands in some places. Crops grow well in areas of Amana and Nodaway soils, but some land leveling and flood protection are required before cropping is feasible. In years when the frequency of rainfall and flooding is below normal, some small streams are used for crops. Without major reclamation, the soils of this unit are better suited to pasture, trees, or wildlife than to crops.

CAPABILITY UNIT VIe-1

This unit consists of sloping to moderately steep soils that occur on the uplands in the highly dissected parts of the county. These soils are in the Adair, Chelsea, Clinton, Gara, Keswick, Lamoni, Lamont, Lindley, and Shelby series. Except for a few areas of Lindley soils that have been protected by trees, these soils are moderately

or severely eroded. The soil properties of the soils in this unit vary widely, but cropping is severely limited on all of the soils by steep slopes and erosion. Runoff is rapid, and some areas are gullied. Much soil would be lost if these soils were cultivated. In places gullies are deep enough to interfere with the use of farm machinery. (fig. 13, bottom).

These soils are well suited to pasture or trees, but are not suited to cultivated crops. Some areas can be used for hay, and other areas are better suited to trees and should be planted to them. Some areas are habitats for wildlife. Except for the Lamont-Clinton-Chelsea complex, 14 to 18 percent slopes, moderately eroded, these soils provide good sites for ponds that supply water to livestock.

Except for the sandier Chelsea and Lamont soils, these soils can be worked within only a narrow range of moisture content. Consequently, the preparation of good seedbeds is often difficult. In places these soils occur in narrow bands within larger areas of more productive soils. If managing the narrow bands separately is not feasible, they can be left in grass when the surrounding soils are cultivated. The many areas that are large enough to manage separately can be used for hay or pasture.

CAPABILITY UNIT VIIe-1

This unit consists of moderately steep and steep Adair, Gara, Gosport, Keswick, Lindley, and Shelby soils and of very steep Chelsea, Clinton, and Lamont soils, which are closely associated and are mapped as a complex. The Adair, Gara, Lindley, Keswick, and Shelby soils developed in glacial till and have a clayey subsoil that is slowly or very slowly permeable. The Gosport soils developed in clayey, very slowly permeable shale. The Clinton soils are silty, and the Chelsea and Lamont soils are sandy and somewhat droughty. Except in some wooded areas of Lindley soils, the soils in this unit are moderately or severely eroded. In cultivated areas, runoff is rapid and erosion is severe. Organic-matter content is low or very low. In some places deep gullies interfere with the use of farm machinery.

Some of these areas have been used for cultivated crops, but many now are used only for hay and pasture. In some places where narrow bands of Adair and Keswick soils adjoin more productive soils, it is advisable to leave these bands in permanent vegetation if the adjoining soils are cultivated.

Except for the Clinton and Chelsea soils, the soils in this unit provide suitable sites for the construction of ponds for watering livestock. Some areas should be planted to trees.

CAPABILITY UNIT VIIs-1

This unit consists of the moderately steep Boone, Chelsea, Dunbarton, and Sogn soils. The Boone soils have a moderately coarse textured surface layer and are underlain by sandstone at a depth of 1½ to 3 feet. The Chelsea soils are coarse textured throughout. The subsoil of the Dunbarton soil developed in weathered reddish clay mixed with limestone flags. This soil is underlain by hard limestone at a depth of about 1½ to 2½ feet. Sogn soils generally are underlain by limestone bedrock at a depth of less than 1½ feet, but in some areas the bedrock is hard sandstone. The soils in this unit are droughty and erodible and not suitable for cultivation.

Most areas of these soils are suitable only for limited grazing. Some areas are in trees. Many areas are small and commonly are left idle when the surrounding soils are cropped. Other areas are in permanent pasture and are left in bluegrass when the surrounding areas are renovated. Plant response to fertilizer generally is poor.

Predicted Yields

The predicted average yields of the principal crops grown in Keokuk County are given in table 3. The estimates are based on the corn yields study (project 1377) made jointly by Iowa State University and the Soil Conservation Service and on observations made by soil scientists and other agricultural workers who are familiar with the soils. These predicted yields are what the soil can be expected to produce over a long period of time, taking into account years of both high and low production.

Yields are given for each soil in the county under two levels of management. In columns A are yields to be expected under the common level of management, or management most farmers were practicing at the time this soil survey was made. In columns B are yields to be expected under a high level of management, or management used by only a small percentage of the farmers in the county.

A variation in yields of about 20 percent can be expected from one year to another and between different areas of the county in any particular year. This variation in yields results from the kind of management used and the amount and timeliness of rainfall. Variations in yields are also caused by insects, disease, and other factors.

The yields in table 3 may be outdated after several years, but they will be useful for many years if they are compared and used as a guide for production indexes. For example, the yields of corn on the Mahaska and Taintor soils were among the highest in the county at the time the estimates were made. These yields can be expected to remain among the highest in the future, even though yields on all soils have generally increased because of new technology and advances in agriculture. In other words, the relation between high-producing soils and low-producing soils in table 3 is expected to remain.

Woodland Management

Practices of woodland management commonly used in the county have resulted in gradual deterioration in the quality of trees. The early settlers prized the woodlands as sources of fuel, posts, and poles, and as material used in building houses and barns and in repairing implements. They harvested the best trees and left those less desirable in form and species. The less desirable trees gradually bcame dominant, and the value of the woodlands was reduced. Then the woodlands were liabilities instead of assets to many farm owners. The woodlands in the county are used mostly for pasture, and improving them is made more difficult by grazing. Some formerly wooded areas have been cleared for farming. Notable among these areas are the Lindley, Clinton, Keswick, Chelsea soils, and some of the soils on bottom lands.

TABLE 3.—*Predicted average acre yields of principal crops under two levels of management*

[Yields in columns A are to be expected under common management; yields in columns B are to be expected under highest feasible level of management. Absence of yields indicates soil is not suitable for the crop or that the crop ordinarily is not grown]

Soil	Corn		Soybeans		Oats		Hay		Pasture	
	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Animal-unit-days* [1]	*Animal-unit-days* [1]
Adair clay loam, 5 to 9 percent slopes, moderately eroded	55	70	18	22	40	50	2.0	2.5	100	125
Adair clay loam, 9 to 14 percent slopes, moderately eroded	50	65	----	----	35	45	1.8	2.2	90	110
Adair soils, 9 to 14 percent slopes, severely eroded	----	----	----	----	25	40	1.0	1.4	50	70
Adair-Shelby complex, 14 to 18 percent slopes, moderately eroded	----	----	----	----	30	45	1.5	2.0	75	100
Adair-Shelby complex, 14 to 18 percent slopes, severely eroded	----	----	----	----	25	40	1.0	1.4	50	70
Alluvial land, channeled	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]
Alluvial land-Nodaway complex	65	90	30	35	45	65	3.0	3.5	150	175
Amana silt loam	90	110	38	43	65	80	3.5	4.0	175	200
Amana silt loam, channeled	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]	[2]
Boone fine sandy loam, 10 to 20 percent slopes	----	----	----	----	----	----	.5	.8	25	40
Chelsea loamy fine sand, 9 to 18 percent slopes	----	----	----	----	40	50	.5	.8	25	40
Chequest silt loam, overwash	70	90	28	35	55	65	3.0	3.5	150	175
Chequest silty clay loam	75	90	30	35	55	65	3.0	3.5	150	175
Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded	40	55	16	20	30	45	1.0	1.5	50	75
Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded	30	45	----	----	25	40	.8	1.2	40	60
Clinton silt loam, 2 to 5 percent slopes	80	95	32	38	55	70	3.6	4.2	180	210
Clinton silt loam, 5 to 9 percent slopes	75	93	30	35	55	65	3.4	4.0	170	200
Clinton silt loam, 5 to 9 percent slopes, moderately eroded	72	90	25	30	50	63	3.0	3.5	150	175
Clinton silt loam, 9 to 14 percent slopes	70	85	22	28	48	60	2.8	3.2	140	160
Clinton silt loam, 9 to 14 percent slopes, moderately eroded	65	80	20	25	45	57	2.5	3.0	125	150
Clinton silt loam, 14 to 18 percent slopes, moderately eroded	60	75	18	22	42	50	2.0	2.6	100	130
Clinton silt loam, benches, 5 to 9 percent slopes, moderately eroded	72	90	25	30	50	63	3.0	3.5	150	175
Clinton soils, 5 to 9 percent slopes, severely eroded	65	85	18	25	45	65	2.2	3.0	110	150
Clinton soils, 9 to 14 percent slopes, severely eroded	60	80	----	----	40	60	2.0	2.8	100	140
Clinton soils, 14 to 18 percent slopes, severely eroded	----	----	----	----	35	55	1.8	2.4	90	120
Colo silt loam, overwash	95	115	40	48	65	82	3.6	4.2	180	210
Colo silty clay loam	95	110	40	45	65	80	3.6	4.2	180	210
Colo silty clay loam, 2 to 5 percent slopes	90	105	40	45	65	80	3.6	4.2	180	210
Colo-Ely silty clay loams, 2 to 5 percent slopes	90	105	40	45	65	80	3.6	4.2	180	210
Dickinson-Sparta complex, 2 to 5 percent slopes	65	80	25	30	45	60	2.0	2.5	100	125
Dickinson-Sparta-Ladoga complex, 5 to 9 percent slopes, moderately eroded	60	75	22	28	40	55	1.8	2.3	90	115
Dickinson-Sparta-Ladoga complex, 9 to 14 percent slopes, moderately eroded	50	65	18	24	35	50	1.5	2.0	75	100
Dunbarton silt loam, 10 to 20 percent slopes, severely eroded	----	----	----	----	----	----	.5	1.0	25	50
Ely silty clay loam, 3 to 7 percent slopes	110	125	42	48	75	87	4.0	4.6	200	230
Gara loam, 9 to 14 percent slopes, moderately eroded	60	75	20	24	40	55	2.0	2.5	100	125
Gara loam, 14 to 18 percent slopes	----	----	----	----	35	50	1.8	2.2	90	110
Gara loam, 14 to 18 percent slopes, moderately eroded	----	----	----	----	30	45	1.6	2.0	80	100
Gara loam, 18 to 25 percent slopes, moderately eroded	----	----	----	----	25	40	1.0	1.5	50	75
Gara soils, 14 to 18 percent slopes, severely eroded	----	----	----	----	20	35	.5	1.0	25	50
Givin silt loam, 1 to 3 percent slopes	105	120	40	45	75	87	4.0	4.5	200	225
Givin silt loam, benches, 1 to 3 percent slopes	105	120	40	45	75	87	4.0	4.5	200	225
Gosport silt loam, 14 to 25 percent slopes, moderately eroded	----	----	----	----	----	----	.5	1.0	25	50
Humeston silt loam	60	80	24	30	45	60	2.6	3.2	130	160
Judson silty clay loam, 3 to 7 percent slopes	110	125	42	48	75	87	4.2	4.8	210	240
Keomah silt loam, 1 to 3 percent slopes	100	115	38	42	70	85	4.0	4.5	200	225
Keswick loam, 9 to 14 percent slopes	50	65	----	----	35	45	1.8	2.2	90	110
Keswick loam, 9 to 14 percent slopes, moderately eroded	40	55	----	----	25	40	1.0	1.4	50	70
Keswick soils, 9 to 14 percent slopes, severely eroded	----	----	----	----	18	35	.8	1.2	40	60
Keswick-Lindley complex, 14 to 18 percent slopes, severely eroded	----	----	----	----	18	30	.5	1.0	25	50
Keswick-Lindley loams, 14 to 18 percent slopes, moderately eroded	----	----	----	----	20	35	.8	1.2	40	60
Koszta silt loam, 1 to 3 percent slopes	95	110	38	42	65	80	3.8	4.2	190	210
Ladoga silt loam, 2 to 5 percent slopes	95	110	38	42	65	80	4.0	4.5	200	225
Ladoga silt loam, 5 to 9 percent slopes	90	105	35	40	60	75	3.8	4.2	190	210
Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	85	100	32	38	55	70	3.6	4.0	180	200
Ladoga silt loam, 9 to 14 percent slopes	82	95	30	35	55	65	3.4	3.8	170	190

See footnotes at end of table.

TABLE 3.—*Predicted average acre yields of principal crops under two levels of management*—Continued

Soil	Corn		Soybeans		Oats		Hay		Pasture	
	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Animal-unit-days* [1]	*Animal-unit-days* [1]
Ladoga silt loam, 9 to 14 percent slopes, moderately eroded	75	90	25	30	50	65	3.0	3.5	150	175
Ladoga silt loam, benches, 2 to 5 percent slopes	95	110	38	42	65	80	4.0	4.5	200	225
Ladoga soils, 5 to 9 percent slopes, severely eroded	75	90	25	30	45	65	3.0	3.5	150	175
Ladoga soils, 9 to 14 percent slopes, severely eroded	65	85	16	25	42	60	2.6	3.0	130	150
Lamoni silty clay loam, 5 to 9 percent slopes, moderately eroded	50	65	18	22	35	50	1.8	2.2	90	110
Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded	40	55	-----	-----	30	45	1.5	2.0	75	100
Lamoni soils, 9 to 14 percent slopes, severely eroded	-----	-----	-----	-----	25	40	1.0	1.5	50	75
Lamoni-Shelby complex, 14 to 18 percent slopes, moderately eroded	-----	-----	-----	-----	25	40	1.0	1.5	50	75
Lamont-Clinton-Chelsea complex, 5 to 9 percent slopes, moderately eroded	50	65	20	25	40	55	1.8	2.2	90	110
Lamont-Clinton-Chelsea complex, 9 to 14 percent slopes, moderately eroded	45	60	16	22	30	45	1.5	2.0	75	100
Lamont-Clinton-Chelsea complex, 14 to 18 percent slopes, moderately eroded	-----	-----	-----	-----	25	40	1.0	1.8	50	90
Lamont-Clinton-Chelsea complex, 18 to 30 percent slopes, moderately eroded	-----	-----	-----	-----	20	35	.8	1.5	40	75
Lindley loam, 9 to 14 percent slopes, moderately eroded	55	70	18	22	35	50	2.0	2.5	100	125
Lindley loam, 14 to 18 percent slopes	-----	-----	-----	-----	35	50	2.0	2.5	100	125
Lindley loam, 14 to 18 percent slopes, moderately eroded	-----	-----	-----	-----	30	45	1.5	2.0	75	100
Lindley loam, 18 to 25 percent slopes	-----	-----	-----	-----	30	45	1.5	2.0	75	100
Lindley loam, 18 to 25 percent slopes, moderately eroded	-----	-----	-----	-----	25	40	1.0	1.5	50	75
Lindley loam, 25 to 40 percent slopes	-----	-----	-----	-----	25	40	1.0	1.5	50	75
Lindley soils, 14 to 18 percent slopes, severely eroded	-----	-----	-----	-----	20	40	1.0	1.8	50	90
Mahaska silty clay loam, 1 to 3 percent slopes	110	130	45	50	75	90	4.5	5.0	225	250
Mahaska silty clay loam, benches, 1 to 3 percent slopes	110	130	45	50	75	90	4.5	5.0	225	250
Martinsburg silt loam, 2 to 5 percent slopes	85	100	35	40	60	70	3.5	4.0	175	200
Martinsburg silt loam, 5 to 9 percent slopes	75	90	30	35	55	65	3.2	3.8	160	190
Nira-Givin complex, 1 to 3 percent slopes	100	115	40	45	70	85	3.8	4.3	190	215
Nira-Mahaska silty clay loams, 1 to 3 percent slopes	105	120	40	45	75	87	4.0	4.5	200	225
Nodaway silt loam	90	110	40	45	65	80	3.5	4.0	175	200
Nodaway silt loam, channeled	([2])	([2])	([2])	([2])	([2])	([2])	([2])	([2])	([2])	([2])
Nodaway-Martinsburg silt loams, 2 to 5 percent slopes	85	100	38	42	60	75	3.3	3.8	165	190
Olmitz loam, 3 to 7 percent slopes	100	115	40	45	70	85	4.0	4.5	200	225
Otley silty clay loam, 2 to 5 percent slopes	105	125	42	48	70	85	4.2	4.8	210	240
Otley silty clay loam, 5 to 9 percent slopes	100	120	40	45	65	80	4.0	4.5	200	225
Otley silty clay loam, 5 to 9 percent slopes, moderately eroded	95	115	38	42	60	75	3.8	4.2	190	210
Otley silty clay loam, 9 to 14 percent slopes, moderately eroded	85	110	30	38	55	70	3.5	4.0	175	200
Radford silt loam	90	110	40	45	65	80	3.4	4.0	170	200
Radford-Ely complex, 2 to 5 percent slopes	90	105	38	42	65	80	3.4	4.0	170	200
Rubio silt loam	70	90	30	38	50	70	2.5	3.5	125	175
Shelby loam, 14 to 18 percent slopes, moderately eroded	-----	-----	-----	-----	35	50	1.8	2.2	90	110
Sogn soils, 15 to 30 percent slopes	-----	-----	-----	-----	-----	-----	.5	.8	25	40
Sperry silt loam	75	95	32	40	55	75	2.8	3.8	140	190
Taintor silty clay loam	105	125	42	48	75	90	4.2	4.8	210	240
Taintor silty clay loam, benches	105	125	42	48	75	90	4.2	4.8	210	240
Tuskeego silt loam	60	80	25	30	45	60	2.6	3.2	130	160
Vesser silt loam	80	100	35	40	60	70	3.5	4.0	175	200
Vesser silt loam, 2 to 5 percent slopes	75	95	32	38	55	65	3.2	3.8	160	190
Wabash silt loam, overwash	70	85	30	35	50	65	3.2	3.8	160	190
Wabash silty clay loam	60	75	25	30	40	55	3.0	3.5	150	175
Watkins silt loam, 0 to 2 percent slopes	105	120	42	48	70	85	4.2	4.8	210	240
Watkins silt loam, 2 to 5 percent slopes	100	115	40	45	65	80	4.0	4.5	200	225
Zook silt loam, overwash	75	90	35	40	60	75	3.5	4.0	175	200
Zook silty clay loam	70	85	32	38	55	70	3.2	3.8	160	190

[1] The number of animal units carried per acre multiplied by the number of days the pasture is grazed during a single season without injury to the sod. Animal-unit-days for an improved pasture is based on the assumption that one mature animal will consume 40 pounds of dry matter per pasture-day.

[2] Variable because of frequent flooding.

Many of the more sloping areas are severely eroded and need to be replanted to suitable trees.

In woodlands the hardwoods are of such poor quality that the best procedure is to replace them with more valuable conifers. Before conifers are planted, however, inferior trees and shrubs that might compete with the conifers should be eliminated by mowing or by spraying with some kind of chemical.

Soils vary in their suitability for trees, and trees vary in ability to grow in various kinds of soils and under various conditions of climate. Generally, the deep, well drained and moderately well drained soils that are medium to high in fertility are well suited to trees. The development of tree roots is related to the permeability of the subsoil. If roots are poorly developed because soil aeration and drainage are poor, trees do not develop normally above the ground.

Native hardwoods generally are not well suited to eroded soils or to soils that have been cultivated. Hardwoods grow better on soils that have not been cultivated, and pines are better suited to eroded or formerly cultivated soils.

Woodland suitability groups

The soils of Keokuk County have been placed in 10 woodland groups according to their suitability for planting trees. Each group is made up of soils that have about the same characteristics and are subject to similar limitations or hazards. All of the soils in a group support similar kinds of trees, have about the same potential productivity, and require similar kinds of management.

Site index ratings are given for most of the woodland groups. The site index is the average height of the dominant and codominant trees in a stand at 50 years of age. It indicates potential soil productivity.

Each woodland group is also rated for hazards that need to be considered in management.

Erosion hazard is rated according to expected erosion that is a result of the cutting and removal of trees. It is *slight* if potential erosion is unimportant; *moderate* if some practices, such as those for diverting water, are needed to prevent accelerated erosion; and *severe* if intensive treatment is needed to control soil losses. Where erosion is severe, special care must be taken in locating and constructing roads and skid trails, in diverting water during and after logging, and in some places, in seeding grasses.

Seedling mortality refers to the expected loss of planted seedlings that is a result of unfavorable soil characteristics, not a result of plant competition. Mortality is *slight* if no more than 25 percent of the seedlings die, *moderate* if 25 to 50 percent of the seedlings die, and *severe* if more than 50 percent of the seedlings die.

Plant competition refers to the rate unwanted brush, grass, vines, or other undesirable plants interfere with the establishment of planted or naturally occurring tree seedlings. Competition is *slight* if unwanted plants do not prevent adequate regeneration or interfere with the early growth of seedlings. Competition is *moderate* if invading plants delay but do not prevent the establishment of seedlings. Competition is *severe* if unwanted plants prevent the growth of the seedlings.

The hazards of *pests and disease* are slight for all the woodland groups of Keokuk County. This means that wood crop losses caused by soil-related pests and diseases are expected to be minimal.

The woodland suitability groups in Keokuk County are discussed in the following pages.

WOODLAND SUITABILITY GROUP 1

This group consists of medium-textured and moderately fine textured, deep, moderately well drained soils in the Clinton, Judson, Ladoga, Martinsburg, Otley, and Watkins series. Slopes range from 0 to 18 percent. The Clinton, Ladoga, and Otley soils are on uplands and make up the largest acreage. The Watkins soils occur on stream benches above the flood plain. The Judson and Martinsburg are gently sloping and occur on foot slopes below the more sloping soils on uplands. Permeability is moderate in the Judson, Martinsburg, and Watkins soils and is moderately slow in the Clinton, Ladoga, and Otley soils. All of the soils have a high available moisture holding capacity.

The suitability of these soils for producing wood crops is excellent. Trees that should be favored in existing stands are walnut, white oak, red oak, green ash, hard maple, basswood, and wild black cherry. For upland hardwoods, the average site index ranges from 76 to 85. In the existing well-managed and fully stocked stands, 250 to 300 or more board feet per acre is produced annually.

Erosion is a moderate to severe hazard on Clinton, Ladoga, and Otley soils and is slight on the Watkins soils. Except where runoff concentrates and small rills and gullies develop, there is little or no erosion on Judson or Martinsburg soils. On all soils, seedling mortality is slight and depends on damage caused by soil-related insects and rodents. Plant competition from grass, weeds, or undesirable trees is slight to moderate. Pest and plant disease hazards generally are slight.

Trees most suitable for planting in woodlots on these soils are the *conifers*, eastern white pine, red pine, Norway spruce, Scotch pine, European larch, and eastern redcedar and the *hardwoods*, walnut, green ash, hackberry, hard maple. Plants most suitable for windbreaks are the *conifers*, eastern white pine, red pine, Norway spruce, white spruce, and eastern redcedar and the *hardwoods*, Norway poplar, Siouxland poplar, robusta poplar, honeysuckle, green ash, and hackberry. The conifers listed as suitable for windbreaks are especially suitable for farmstead windbreaks and the hardwoods for field windbreaks. Species suitable for wildlife planting are honeysuckle, viburnum, ninebark, lilac, and dogwood.

WOODLAND SUITABILITY GROUP 2

This group consists of deep, moderately well drained soils in the Gara, Lindley, Olmitz, and Shelby series. Except for the Olmitz soil, which occurs on foot slopes and is gently sloping, these soils occur in the uplands. Slopes range from 3 to 18 percent. Permeability is moderate and moderately slow, and available moisture holding capacity is high.

The suitability of these soils for producing trees is good to very good. Trees that should be favored in existing stands are red oak, white oak, green ash, black walnut, basswood, hackberry, and hard maple. For up-

land hardwoods, the average site index ranges from 56 to 75. In the existing stands, 180 to 230 board feet per acre is produced annually.

Erosion is a moderate to severe hazard on the Gara, Lindley, and Shelby soils. Except where runoff concentrates and small rills or gullies develop, there is little or no erosion on the Olmitz soils. Seedling mortality is generally slight and depends on the damage caused by insects and rodents. Plant competition from grasses, weeds, or other undesirable plants is slight to moderate.

Trees most suitable for planting in woodlots on these soils are the *conifers*, eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, European larch, and Douglas-fir, and the *hardwoods*, black walnut, green ash, and hackberry. Plants most suitable for windbreaks are the *conifers*, eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, and Douglas-fir, and the *hardwoods*, Norway poplar, Siouxland poplar, robusta poplar, honeysuckle, green ash, and hackberry. The conifers listed are especially suitable for farmstead windbreaks and the hardwoods for field windbreaks. Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, and dogwood.

WOODLAND SUITABILITY GROUP 3

This group consists of medium-textured, deep, moderately well drained Gara and Lindley soils on uplands. These soils have slopes ranging from 18 to 40 percent, and the steepest soils are dominant. Slopes generally face north and northeast. Permeability is moderately slow, and available moisture holding capacity is high. Surface runoff is rapid.

The suitability of these soils for producing trees is good. Stands of trees grow on the soils of this group in many areas, but the trees commonly are of low quality. The ones that should be favored in existing stands are red oak, white oak, green ash, black walnut, basswood, hackberry, and hard maple. For upland hardwoods, the average site index ranges from 56 to 65. In the existing stands from 150 to 200 board feet per acre is produced annually.

The erosion hazard is severe on these soils. Seedling mortality generally is slight and depends on the damage caused by soil-related insects and rodents. Plant competition from grasses, weeds, or other undesirable plants is moderate.

Trees most suitable for planting in woodlots on these soils are the *conifers*, eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, European larch, and Douglas-fir, and the *hardwoods*, black walnut, green ash, and hackberry. Plants most suitable for windbreaks are the *conifers*, eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, and Douglas-fir, and the *hardwoods*, Norway poplar, Siouxland poplar, robusta poplar, honeysuckle, green ash, and hackberry. The conifers listed are especially suitable for farmstead windbreaks and the hardwoods for field windbreaks. Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, and dogwood.

WOODLAND SUITABILITY GROUP 4

This group consists of deep, somewhat poorly drained, medium-textured and moderately fine textured soils in the Ely, Givin, Keomah, Koszta, Mahaska, and Nira series. The Givin, Keomah, Mahaska, and Nira soils are dominant and occur in the uplands. The Ely soils are gently sloping and occur on foot slopes. Koszta soils occur on second bottoms and are nearly level. Except in a few slightly more sloping areas of Ely soils, slopes range from 1 to 3 percent. Runoff is slow, permeability is moderate and moderately slow, and available moisture holding capacity is high.

The suitability of these soils for producing trees is good. Stands of trees grow in some areas on the soils in this group, but the trees commonly are of poor quality. The ones that should be favored in existing stands are red oak, white oak, green ash, black walnut, basswood, hackberry, and hard maple. For upland hardwoods, the average site index ranges from 56 to 65. In the existing stands from 150 to 200 board feet per acre is produced annually.

These soils are subject to little or no erosion. Seedling mortality is generally slight and depends on the damage caused by soil-related insects and rodents. Plant competition from undesirable species is moderate.

Trees most suitable for planting in woodlots on these soils are the *conifers*, eastern white pine, Scotch pine, red pine, Norway spruce, eastern redcedar, and European larch, and the *hardwoods*, green ash, walnut, and hackberry. Plants most suitable for windbreaks are the *conifers*, eastern white pine, Scotch pine, red pine, Norway spruce, and eastern redcedar, and the *hardwoods*, Norway poplar, Siouxland poplar, robusta poplar, honeysuckle, green ash, and hackberry. The conifers listed are especially suitable for farmstead windbreaks and the hardwoods for field windbreaks. Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, and dogwood.

WOODLAND SUITABILITY GROUP 5

This group consists of deep, dominantly coarse textured, gently sloping to steep soils of the uplands. These soils are in the Chelsea, Clinton, Dickinson, Ladoga, Lamont, and Sparta series. They are well drained to excessively drained and have rapid permeability. The dominant Chelsea, Dickinson, Lamont, and Sparta soils are coarse textured and have a low to very low available water holding capacity. The Clinton and Ladoga soils are medium textured and have a high available water holding capacity, but they are closely associated with coarse-textured, droughty soils.

The suitability of these soils for producing trees is fair to poor. Stands of trees grow in some areas on the soils of this group, but the trees commonly are of low quality. The ones that should be favored in existing stands are red oak, white oak, green ash, hackberry, and cottonwood. The average site index for upland hardwoods generally ranges from 46 to 55. In the existing stands from 100 to 150 board feet per acre generally is produced annually. On slopes of more than 18 percent that face south and southwest, the site index is less than 45 and annual production is less than 100 board feet per acre.

Erosion is a moderate to severe hazard on these soils. Seedling mortality is slight and depends on damage caused by insects and rodents and on the timeliness of rainfall. Plant competition from grasses, weeds, or other undesirable species is slight to moderate.

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Trees most suitable for planting in woodlots on these soils are the *conifers*, eastern white pine, red pine, Scotch pine, European larch, and eastern redcedar. Plants most suitable for windbreaks are the *conifers*, eastern white pine, red pine, Scotch pine, and eastern redcedar, and the *hardwoods*, Norway poplar, Siouxland poplar, robusta poplar, honeysuckle, green ash, and hackberry. The conifers listed are especially suitable for farm windbreaks, and the hardwoods are suitable for field windbreaks. Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, and dogwood.

WOODLAND SUITABILITY GROUP 6

This group consists of shallow-to-bedrock, excessively drained soils in the Boone, Dunbarton, and Sogn series. Slopes range from 10 to 30 percent, and runoff is rapid. Available water holding capacity is very low.

These soils are poorly suited to trees. In areas where trees grow, most of them are of low quality. Trees that should be favored in existing stands are green ash, hackberry, red oak, and white oak. For upland hardwoods, the average site index is 45 or less. In the existing stands, less than 100 board feet per acre is produced annually.

Erosion is a moderate to severe hazard on these soils. Seedling mortality is slight to severe and depends on timeliness of rainfall and insect and rodent damage.

Trees most suitable for planting in woodlots on these soils are the *conifers*, eastern white pine, Scotch pine, red pine, and European redcedar. Trees most suitable for windbreaks are the *conifers*, eastern white pine, Scotch pine, red pine, and eastern redcedar. Species suitable for wildlife habitats are honeysuckle and ninebark.

WOODLAND SUITABILITY GROUP 7

This group consists of medium- and moderately fine textured, moderately well and somewhat poorly drained soils of the uplands. These soils are in the Adair, Keswick, Lindley, and Shelby series. Slopes range from 5 to 18 percent. Permeability is slow and moderately slow, and available water holding capacity is high. Runoff is moderate to high.

The suitability of these soils for trees is fair to good. Although trees grow on these soils in some places, they commonly are of low quality. Trees that should be favored in existing stands are green ash, hackberry, white oak, and red oak. For hardwoods, the average site index ranges from 45 to 65. In existing stands 100 to 200 board feet per acre is produced annually.

Erosion is a moderate to severe hazard on these soils. Seedling mortality is slight. Plant competition from undesirable species is slight.

Trees most suitable for planting in woodlots on these soils are the *conifers*, eastern white pine, Scotch pine, eastern redcedar, Norway spruce, and the *hardwoods*, green ash and hackberry. Plants most suitable for windbreaks are the *conifers*, eastern white pine, Scotch pine, eastern redcedar, and Norway spruce, and the *hardwoods*, Norway poplar, Siouxland poplar, robusta poplar, honeysuckle, green ash, and hackberry. The conifers listed are especially suitable for farmstead windbreaks and the hardwoods for field windbreaks. Species suitable for wildlife plantings are dogwood, buttonbush, and pussy willow.

WOODLAND SUITABILITY GROUP 8

This group consists of moderately well drained to poorly drained, moderately fine and fine textured soils on uplands. These soils are in the Clarinda, Gosport, Lamoni, and Shelby series. Slopes range from 5 to 25 percent, and runoff is rapid. Permeability is moderately slow to very slow, and available water holding capacity is high. The soils in this group are seasonally wet and seepy.

The suitability of these soils for trees is fair to poor. For upland hardwoods, the average site index is less than 45. In the existing stands, less than 100 board feet per acre is produced annually.

Erosion is a moderate to severe hazard on these soils. Seedling mortality and plant competition are slight.

Trees most suitable for planting in woodlots on these soils are the *conifers*, redcedar and Scotch pine, and the *hardwoods*, green ash, hackberry, and cottonwood. These same trees are also suitable for windbreaks, but the conifers listed are especially suitable for farmstead windbreaks and the hardwoods for field windbreaks.

WOODLAND SUITABILITY GROUP 9

This group consists of deep, moderately well drained to somewhat poorly drained, medium-textured soils on nearly level bottom lands. These soils are subject to frequent flooding. Runoff is slow, permeability is dominantly moderate, and available water holding capacity is high. In this group are soils in the Amana, Ely Martinsburg, Nodaway, and Radford series and Alluvial land.

The suitability of these soils for bottom-land hardwoods is good. In the existing stands, 300 to 700 board feet per acre is produced annually.

Erosion normally is not a hazard. Some gullying occurs where water concentrates in drainageways in Radford-Ely complex, 2 to 5 percent slopes, and Nodaway-Martinsburg silt loams, 2 to 5 percent slopes. Plant competition is slight, and seedling mortality generally is slight.

Trees most suitable for planting in woodlots and in windbreaks on these soils are the *bottom-land hardwoods*, cottonwood, soft maple, and green ash. These soils are not well suited to upland hardwoods or to conifers. Species suitable for wildlife plantings are dogwood, buttonbush, and pussy willow.

WOODLAND SUITABILITY GROUP 10

This group consists of poorly drained soils of the uplands and bottom lands. These soils are medium and moderately fine textured, are slowly permeable, and have a high available moisture capacity. They are in the Chequest, Colo, Ely, Humeston, Rubio, Sperry, Taintor, Tuskeego, Vesser, Wabash, and Zook series. The Chequest, Colo, Humeston, Vesser, and Wabash soils are subject to flooding, and the Rubio, Sperry, and Tuskeego soils are subject to ponding from runoff.

Suitability for trees is only fair, but the soils on bottom lands are better suited to trees than the soils on uplands. In the existing stands on bottom lands, 200 to 500 board feet per acre is produced annually.

Trees best suited to planting in woodlots on these soils are soft maple, cottonwood, sycamore, willow, green ash, and hackberry. Conifers are not well suited. Trees most suitable for windbreaks are cottonwood, soft maple, and

green ash. Cottonwood and soft maple are particularly well suited to windbreaks. Species suitable for wildlife planting are dogwood, buttonbush, and pussy willow.

Use of the Soils for Engineering

For a long time engineers have studied soil properties that affect construction and have devised systems of soil classification based on these characteristics. Most of these studies have been at the site of construction because general information about the soils of an area has not been available.

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, facilities for storing water, erosion control structures, irrigation systems, drainage systems, building foundations, and sewage disposal systems. Among the properties that are most important are permeability to water, shear strength, compaction characteristics, soil drainage, shrink-swell potential, grain size, plasticity, and reaction (pH). Also important are depth to the water table, depth to bedrock, and topography.

The information in this survey can be used by engineers to—

1. Make studies of soil and land use that will aid in the selection and development of industrial, business, residential, and recreational sites.
2. Assist in planning and designing drainage and irrigation structures and in planning dams and other structures for water and soil conservation.
3. Make preliminary evaluation of soil and ground conditions that will aid in selecting highway and airport locations and in planning more detailed investigations at the selected locations.
4. Locate probable sources of sand, gravel, or other construction material.
5. Correlate performance of engineering structures with soil mapping units to develop information for planning that will be useful in designing and maintaining specified engineering structures.
6. Determine the suitability of soil mapping units for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps and reports, and from aerial photographs, for the purpose of making maps and reports that can be readily used by engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

With the use of the soil map for identification, the interpretations in this survey can be useful to the planning engineer. It should be emphasized, however, that these interpretations may not eliminate the need for sampling and testing at the site of specific engineering works that involve heavy loads or where the excavations are deeper than the depth of layers reported. Even in these situations, however, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

Information regarding the properties and behavior of the soils in Keokuk County can be obtained from the detailed soil map at the back of this survey and from tables 4, 5, 6. The information in the tables was obtained in the field and was evaluated by observation of soil performance and by considering the results of tests such as those shown in table 6. A specific value in pounds per square foot should not be assigned to the ratings of bearing capacity.

Some of the terms used by soil scientists may have a special meaning in soil science and may be unfamiliar or have a special meaning to engineers. Many of these terms are defined in the Glossary at the back of this survey. Information valuable to engineers is also in the sections "Descriptions of the Soils" and "Formation and Classification of Soils."

Engineering classification systems

Most highway engineers classify soil materials in accordance with the system approved by the American Association of State Highway Officials (AASHO) (*1*). In this system soil materials are classified on the basis of field performance in seven principal groups. The groups range from A–1, consisting of gravelly soil of high bearing capacity, to A–7, which is made up of clayey soils having low strength when wet.

Some engineers prefer to use the Unified soil classification system (*19*). In this system, soil materials are identified as coarse grained (eight classes), fine grained (six classes), or highly organic (one class). An approximate classification can be made in the field. Estimated classification of the soils in Keokuk County, under both systems, is given in table 4. Because of their highly variable properties, Alluvial land, channeled, and Alluvial land-Nodaway complex are not included in this table.

Engineering properties of the soils

In table 4, the soil series in Keokuk County are listed and estimates of soil properties are given. These estimates are based on the test data in table 6, on information in other parts of this survey, and on experience with the same kind of soil in other counties.

Depth to bedrock is not given in table 4, because bedrock is below most soils in the county at a depth of more than 5 feet. The Boone soil, however, has soft sandstone at a depth of about 25 inches, the Dunbarton soil has limestone flags at a depth of about 24 inches, and the Sogn soil has fractured limestone at a depth of about 15 inches.

Depth to a seasonal high water table is important because it indicates soils that may be seasonally wet or flooded.

In table 4, the soils of the county are classified according to the dominant texture of layers at specified depths. The United States Department of Agriculture defines texture as the proportion of sand, silt, and clay. The soils are also classified according to the Unified and AASHO systems. The percentage of material passing No. 4, 10, and 200 sieves is the normal range in percentage of soil particles passing the respective screens.

Permeability refers to the rate of movement of water through the undisturbed soil. Permeability depends largely on the soil texture and structure.

Available water capacity is estimated in inches per inch of soil depth. It is the approximate amount of water in the soil, when it is wet to field capacity, that can be removed by plants. These estimates are of particular value to engineers engaged in irrigation.

TABLE 4.—*Estimated*

Soil series and map symbol	Depth to seasonal high water table [1]	Depth from surface	Classification	
			Dominant USDA texture	Unified
	Feet	*Inches*		
Adair: AaC2, AaD2, AdD3, AhE2, AhE3 (For properties of Shelby soils in mapping units AhE2 and AhE3, refer to Shelby series.)	(2)	0–11	Clay loam	CL
		11–31	Clay to clay loam	CH or CL
		31–52	Clay loam	CL
Amana: An, Ao	1–3	0–18	Silt loam	ML or CL
		18–51	Silty clay loam	ML or CL
		51–65	Silt loam	ML or CL
Boone: BoE	>5	0–10	Fine sandy loam	SM or SC
		10–25	Fine sand	SM or SP–SM
		25	Soft sandstone.	
Chelsea: CaE	>5	0–15	Loamy fine sand	SM
		15–54	Fine sand	SM or SP
Chequest: Cc	1–3	0–14	Light silty clay loam	ML or CL
		14–38	Silty clay loam	CL or CH
		38–56	Silty clay	CH
Chequest, overwash: Cb	1–3	0–20	Silt loam	ML or CL
		20–31	Silty clay loam	CL–CH
		31–56	Silty clay to silty clay loam	CH
Clarinda: CdC2, CdD2	(2)	0–11	Silty clay loam	CL
		11–17	Silty clay	CH
		17–59	Silty clay or clay	CH
Clinton: ClB ClC, ClC2, ClD, ClD2, ClE2, CmC2, CnC3, CnD3 CnE3.	>5	0–15	Silt loam	ML–CL
		15–47	Silty clay loam	CL or CH
		47–84	Silty clay loam	CL
Colo, overwash: Co	1–3	0–20	Silt loam and silty clay loam	ML or CL
		20–42	Silty clay loam	CL or CH
		42–72	Silty clay loam	CL or CH
Colo: Cs, CsB, CtB (For properties of Ely soil in mapping unit CtB, refer to Ely series.)	1–3	0–42	Silty clay loam	CL or CH
		42–72	Silty clay loam	CL or CH
Dickinson: DhB, DlC2, DlD2 (For properties of Sparta soils in these mapping units, refer to the Sparta series and for properties of Ladoga soils in DlC2 and DlD2, refer to Ladoga series.)	>5	0–13	Sandy loam	SM or SC
		13–44	Sandy loam	SM or SC
		44–56	Loamy sand	SM
Dunbarton: DuE3	>5	0–5	Silt loam	CL
		5–24	Clay	CH
		24	Limestone flags.	
Ely: ElB	2–5	0–32	Silty clay loam	CL
		32–58	Silty clay loam	CL
		58–65	Silty clay loam	CL
Gara: GaD2, GaE, GaE2, GaF2, GrE3	>5	0–12	Loam to clay loam	CL
		12–43	Clay loam	CL
		43–56	Clay loam	CL
Givin: GsA, GtA	2–5	0–12	Silt loam	ML or CL
		12–42	Medium to heavy silty clay loam.	ML or CL
		42–50	Light silty clay loam	CL

See footnotes at end of table.

engineering properties of soils

Classification—Con.	Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
				Inches per hour	*Inches per inch of soil*	*pH value*	
A-6(8-12)	95-100	80-95	60-80	0. 63-2. 0	0. 18	5. 6-6. 5	Moderate.
A-7-6(15-20)	95-100	80-95	70-90	<0. 05	0. 16	5. 1-6. 0	High.
A-6(10) to A-7-6(14)	95-100	80-95	55-70	0. 2-0. 63	0. 15	5. 6-6. 5	Moderate.
A-6(8) to A-7-6(12)	----------	100	95-100	0. 63-2. 0	0. 20	6. 1-6. 5	Moderate.
A-7-6(11-15)	----------	100	95-100	0. 63-2. 0	0. 19	5. 6-6. 0	Moderate.
A-7-6(9-12)	----------	100	95-100	0. 63-2. 0	0. 17	6. 1-6. 5	Moderate.
A-2 or A-4	----------	85-100	25-50	2. 0-6. 3	0. 12	5. 6-6. 5	Low.
A-3	----------	85-100	5-15	>6. 3	0. 02	5. 6-6. 0	None.
A-2	100	95-100	10-35	>6. 3	0. 04	5. 6-6. 5	None.
A-2 or A-3	100	95-100	8-20	>6. 3	0. 02	5. 6-6. 0	None.
A-7-6(16-20)	----------	100	95-100	0. 63-2. 0	0. 18	5. 1-6. 0	Moderate.
A-7-6(16-20)	----------	100	95-100	0. 05-0. 2	0. 20	5. 1-5. 5	Moderate to high.
A-7-6(20)	----------	100	95-100	0. 02-0. 63	0. 20	6. 1-7. 3	Moderate to high.
A-6(6-10)	100	95-100	90-100	0. 63-2. 0	0. 20	7. 4-7. 8	Moderate.
A-7-6(16-20)	----------	100	95-100	0. 05-0. 2	0. 20	5. 1-5. 5	Moderate to high.
A-7-6(20)	----------	100	95-100	0. 02-0. 63	0. 20	6. 1-7. 3	Moderate to high.
A-6(6-10) to A-7-6(14)	100	95-100	85-100	0. 2-0. 63	0. 18	6. 6-7. 3	Moderate to high.
A-7-6(20)	100	95-100	85-100	<0. 05	0. 15	5. 6-6. 0	High.
A-7-6(20)	95-100	90-100	75-90	<0. 05	0. 15	5. 6-7. 3	High.
A-4(8) to A-6(12)	----------	100	95-100	0. 63-2. 0	0. 18	5. 6-6. 5	Moderate.
A-7-6(14-18)	----------	100	95-100	0. 2-0. 63	0. 20	5. 1-6. 0	Moderate to high.
A-6(10) to A-7-6(16)	----------	100	95-100	0. 63-2. 0	0. 18	5. 6-6. 5	Moderate.
A-6(6-10)	100	95-100	90-100	0. 63-2. 0	0. 20	7. 4-7. 8	Moderate.
A-7-6(14-19)	----------	100	85-100	0. 2-0. 63	0. 21	6. 1-6. 5	High to moderate.
A-7-6(14-19)	----------	100	90-100	0. 2-0. 63	0. 20	6. 1-7. 3	High to moderate.
A-7-6(14-19)	----------	100	85-100	0. 2-0. 63	0. 21	6. 1-6. 5	High to moderate.
A-7-6(14-19)	----------	100	90-100	0. 2-0. 63	0. 20	6. 1-7. 3	High to moderate.
A-2 or A-4	100	80-90	25-50	2. 0-6. 3	0. 12	5. 6-6. 0	Low.
A-2 or A-4	100	80-90	25-50	2. 0-6. 3	0. 10	5. 6-7. 3	Low.
A-2-4	100	75-90	20-35	>6. 3	0. 03	6. 6-7. 3	Low to none.
A-6(10 to 12)	----------	100	95-100	0. 63-2. 0	0. 18	6. 1-6. 5	Moderate.
A-7-6(20)	90-100	80-100	70-100	<0. 05	0. 16	6. 6-7. 3	High.
A-7-6(12-17)	100	95-100	90-100	0. 63-2. 0	0. 20	5. 6 6. 5	Moderate to high.
A-7-6(12-17)	100	95-100	90-100	0. 63-2. 0	0. 20	6. 1-7. 3	Moderate to high.
A-6(12) to A-7-6(14)	100	95-100	90-100	0. 63-2. 0	0. 18	6. 6-7. 3	Moderate to high.
A-4(4)	95-100	80-90	50-65	0. 63-2. 0	0. 18	5. 1-6. 5	Moderate.
A-6(8) to A-7-6(14)	95-100	80-95	50-70	0. 2-0. 63	0. 17	4. 5-6. 0	Moderate to high.
A-6(8) to A-7-6(14)	95-100	80-95	50-70	0. 2-0. 63	0. 15	6. 6-7. 3	Moderate.
A-4(8) to A-6(10)	----------	100	95-100	0. 63-2. 0	0. 16	5. 6-6. 0	Moderate.
A-7-6(14-18)	----------	100	95-100	0. 2-0. 63	0. 20	5. 1-6. 0	Moderate to high.
A-7-6(12-16)	----------	100	95-100	0. 63-2. 0	0. 18	5. 6-6. 0	Moderate.

TABLE 4.—*Estimated engineering*

Soil series and map symbol	Depth to seasonal high water table [1]	Depth from surface	Classification	
			Dominant USDA texture	Unified
	Feet	*Inches*		
Gosport: GuE2	>5	0–5	Silt loam or silty clay loam	ML–CL
		5–22	Silty clay	CH
		22–47	Silty clay shale	CH
Humeston: Hu	1–3	0–15	Silt loam	ML–CL
		15–57	Silty clay	CH
Judson: JcC	>5	0–30	Silty clay loam	CL
		30–60	Silty clay loam	CL
Keomah: KeA	2–5	0–17	Silt loam	ML or CL
		17–41	Silty clay loam to silty clay	CL or CH
		41–61	Silty clay loam	CL
Keswick: KsD, KsD2, KwD3, KxE3, KyE2 (For properties of the Lindley soils in mapping units KxE3 and KyE2, refer to Lindley series.)	[2]	0–9	Loam to silt loam	CL
		9–39	Clay and clay loam	CH
		39–64	Clay loam and sandy clay loam	CL or SC
Koszta: KzA	2–5	0–20	Silt loam	ML or CL
		20–68	Silty clay loam	CL
Ladoga: LaB, LaC, LaC2, LaD, LaD2, LbB, LdC3, LdD3	>5	0–14	Silt loam	ML or CL
		14–33	Silty clay loam to silty clay	CL or CH
		33–54	Silty clay loam	CL
Lamoni: LmC2, LmD2, LnD3, LoE2 (For properties of Shelby soil in mapping unit LoE2, refer to Shelby series.)	[2]	0–15	Silty clay loam	CL
		15–38	Clay and clay loam	CH
		38–53	Clay loam	CL
Lamont: LpC2, LpD2, LpE2, LpF2 (For properties of Clinton soil and Chelsea soil in these mapping units, refer to the Clinton and Chelsea series.)	>5	0–7	Fine sandy loam	SM or ML
		7–36	Sandy loam	SM or SC
		36–57	Loamy fine sand and sand	SM
Lindley: LrD2, LrE, LrE2, LrF, LrF2, LrG, LsE3	>5	0–7	Loam	ML–CL
		7–33	Clay loam	CL
		33–58	Sandy clay loam	CL or SC
Mahaska: MaA, MhA	2–5	0–18	Silty clay loam	ML–CL
		18–40	Silty clay loam and silty clay	CH
		40–61	Silty clay loam and silt loam	CL
Martinsburg: MrB, MrC	>5	0–20	Silt loam	ML or CL
		20–96	Silty clay loam	CL
		96–106	Silt loam to silty clay loam	CL
Nira: NgB, NmB (For properties of Givin soil in mapping unit NgB, refer to Givin series and for properties of Mahaska soil in NmB, refer to Mahaska series.)	2–5	0–10	Silty clay loam	ML or CL
		10–22	Silty clay loam	CL–CH
		22–60	Silty clay loam	CL
Nodaway: No, Ns, NwB (For properties of Martinsburg soil in mapping unit NwB, refer to Martinsburg series.)	2–5	0–55	Silt loam	ML or CL
Olmitz: OlC	>5	0–29	Loam and clay loam	CL
		29–60	Clay loam	CL
Otley: OtB, OtC, OtC2, OtD2	>5	0–17	Silty clay loam	CL
		17–40	Silty clay loam to silty clay	CL or CH
		40–61	Silty clay loam and silt loam	CL

See footnotes at end of table.

properties of soils—Continued

Classification—Con.	Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
				Inches per hour	*Inches per inch of soil*	*pH value*	
A-6		100	85–100	0. 63–2. 0	0. 17	5. 6–6. 5	Moderate.
A-7-6(20)		100	95–100	<0. 05	0. 15	4. 5–6. 0	High.
A-7-6(20)		100	95–100	<0. 05	0. 15	4. 5–6. 0	High.
A-4(6) to A-6(8–10)		100	95–100	0. 63–2. 0	0. 20	6. 1–7. 3	Moderate.
A-7-6(20)		100	95–100	0. 05–0. 2	0. 18	6. 1–7. 8	High.
A-6(9) to A-7-6(13)		100	90–100	0. 63–2. 0	0. 22	5. 6–7. 3	Moderate.
A-6(10) to A-7-6(12)		100	90–100	0. 63–2. 0	0. 20	5. 6–6. 5	Moderate.
A-4(8) to A-6(10)		100	95–100	0. 63–2. 0	0. 18	5. 6–7. 3	Moderate to low.
A-7-6(16–18)		100	95–100	0. 2–0. 63	0. 18	5. 1–6. 0	High.
A-6(10) to A-7-6(13)		100	95–100	0. 63–2. 0	0. 18	5. 6–6. 5	Moderate to high.
A-6(8–12)	95–100	80–100	60–80	0. 63–2. 0	0. 17	5. 6–6. 5	Moderate.
A-7-6(14–20)	95–100	80–100	55–80	<0. 05	0. 16	5. 1–6. 0	High.
A-6(6–12)	95–100	70–100	40–70	0. 2–0. 63	0. 15	6. 1–7. 3	Moderate.
A-4(8) to A-6(12)		100	95–100	0. 63–2. 0	0. 19	5. 1–6. 0	Moderate.
A-7-6(11–14)		100	95–100	0. 63–2. 0	0. 18	5. 1–5. 5	Moderate to high.
A-4(8) to A-6(12)		100	95–100	0. 63–2. 0	0. 18–0. 23	5. 6–6. 5	Moderate.
A-7-6(12–15)		100	95–100	0. 2–0. 63	0. 19–0. 21	5. 1–6. 0	Moderate to high.
A-6(10) to A-7-6(13)		100	95–100	0. 63–2. 0	0. 17–0. 21	5. 6–6. 0	Moderate.
A-6(10) to A-7-6(12)	95–100	90–100	70–95	0. 63–2. 0	0. 18	6. 6–7. 2	Moderate to high.
A-7-6(16–20)	95–100	80–100	75–90	0. 05–0. 2	0. 18	5. 6–6. 5	High.
A-6(10) to A-7-6(15)	85–100	80–100	55–85	0. 2–0. 63	0. 16	6. 1–7. 2	Moderate to high.
A-2-4 or A-4		90–100	40–55	2. 0–6. 3	0. 12	6. 1–6. 5	Low.
A-2-4 or A-4		90–100	25–45	2. 0–6. 3	0. 10	5. 6–6. 0	Low.
A-2-4		80–100	15–25	>6. 3	0. 04	6. 1–7. 3	Low.
A-4(3) to A-6(8)	95–100	95–100	50–65	0. 63–2. 0	0. 17	4. 5–6. 5	Low to moderate.
A-6(9) to A-7-6(14)	95–100	85–95	50–70	0. 2–0. 63	0. 15	<4. 5–5. 5	Moderate.
A-6(6–10)	95–100	85–95	45–70	0. 2–0. 63	0. 14	4. 5–7. 3	Moderate.
A-7-6(12–16)		100	95–100	0. 63–2. 0	0. 22	4. 5–6. 0	Moderate to high.
A-7-6(16–20)		100	95–100	0. 2–0. 63	0. 20	4. 5–5. 5	High.
A-7-6(14–18)		100	95–100	0. 63–2. 0	0. 18	5. 6–7. 8	Moderate to high.
A-4(6–8)		100	95–100	0. 63–2. 0	0. 19	5. 6–6. 0	Low to moderate.
A-7-6(12–15)		100	95–100	0. 63–2. 0	0. 18	5. 1–6. 0	Low to moderate.
A-4(6) to A-6(10)		100	95–100	0. 63–2. 0	0. 16	5. 6–6. 0	Low to moderate.
A-7-6(8–10)		100	95–100	0. 63–2. 0	0. 20	5. 6–6. 5	Moderate.
A-7-6(10–16)		100	95–100	0. 2–0. 63	0. 20	5. 1–6. 0	Moderate to high.
A-6(10) to A-7-6(12)		100	75–100	0. 63–2. 0	0. 18	5. 6–6. 5	Moderate to high.
A-6(8–10)	100	95–100	90–100	0. 63–2. 0	0. 20	7. 4–7. 8	Moderate.
A-6(8–10)	95–100	90–100	60–80	0. 63–2. 0	0. 20	5. 6–7. 3	Moderate.
A-6(8–12)	95–100	90–100	60–80	0. 63–2. 0	0. 18	5. 6–6. 0	Moderate.
A-7-6(10–12)		100	95–100	0. 63–2. 0	0. 20	5. 1–6. 0	Moderate to high.
A-7-6(14–18)		100	95–100	0. 2–0. 63	0. 18	4. 5–5. 5	Moderate to high.
A-7-6(11–15)			95–100	0. 63–2. 0	0. 17	5. 6–7. 3	Moderate to high.

TABLE 4.—*Estimated engineering*

Soil series and map symbol	Depth to seasonal high water table [1]	Depth from surface	Classification: Dominant USDA texture	Classification: Unified
	Feet	*Inches*		
Radford: Ra, ReB (For properties of Ely soil in mapping unit ReB, refer to Ely series.)	2–5	0–23	Silt loam	ML or CL
		23–54	Silty clay loam	CL or CH
Rubio: Ru	0–2	0–14	Silt loam	ML or CL
		14–46	Silty clay loam and silty clay	CH
		46–53	Silty clay loam	CL
Shelby: ShE2	>5	0–12	Loam	CL
		12–40	Clay loam	CL
		40–60	Clay loam	CL
Sogn: SoF	>5	0–15	Loam	CL
		15	Fractured limestone.	
Sparta (Mapped only with Dickinson soils.)	>5	0–18	Loamy fine sand	SM
		18–32	Fine sand	SM
		32–53	Fine to medium sand	SM or SP
Sperry: Sp	0–2	0–20	Silt loam	ML or CL
		20–43	Silty clay and silty clay loam	CH
		43–60	Silty clay loam	CL
Taintor: Ta, Tb	1–3	0–17	Silty clay loam and silty clay	CL or CH
		17–34	Silty clay loam and silty clay	CH
		34–70	Silty clay loam and silt loam	CH or CL
Tuskeego: Tu	1–3	0–12	Silt loam	ML or CL
		12–39	Silty clay loam to silty clay	CH
		39–55	Silty clay loam to silty clay	CH
Vesser: Ve, VeB	2–5	0–13	Silt loam	ML or CL
		13–23	Silt loam	ML or CL
		23–58	Silty clay loam	CL or CH
Wabash, overwash: Wa	1–3	0–18	Silt loam	ML or CL
		18–49	Silty clay	CH
		49–57	Silty clay loam to silty clay	CH–CL
Wabash: Wc	0–2	0–11	Silty clay loam	CH–MH
		11–37	Silty clay	CH
		37–57	Silty clay loam to silty clay	CH
Watkins: WkA, WkB	>5	0–12	Silt loam	ML or CL
		12–60	Silty clay loam	CL
Zook: Zo	1–3	0–21	Silty clay loam	CL or CH
		21–45	Light silty clay	CH
		45–55	Silty clay loam or silty clay	CH–CL
Zook, overwash: Zk	1–3	0–18	Silt loam	ML or CL
		18–38	Silty clay loam	CL or CH
		38–60	Silty clay	CH

[1] Depths are for undrained areas. In wet soils that are tiled, the water table is generally below the tile line at depths of 3 to 4 feet.

properties of soils—Continued

Classification—Con.	Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
				Inches per hour	*Inches per inch of soil*	*pH value*	
A-4(8) to A-6(10)	100	95-100	90-100	0. 63-2. 0	0. 18	6. 1-7. 3	Moderate to high.
A-7-6(15)	------------	100	85-100	0. 2-0. 63	0. 20	6. 6-7. 3	High.
A-4(6) to A-6(10)	------------	100	95-100	0. 63-2. 0	0. 18	5. 6-7. 3	Moderate.
A-7-6(14-20)	------------	100	95-100	0. 2-0. 63	0. 18	5. 1-6. 5	High.
A-6(10) to A-7-6(12)	------------	100	95-100	0. 63-2. 0	0. 17	6. 6-7. 3	Moderate to high.
A-6(8-10)	95-100	95-100	50-65	0. 63-2. 0	0. 20	6. 1-6. 5	Moderate.
A-6(8) to A-7-6(12)	95-100	85-95	50-70	0. 2-0. 63	0. 18	5. 6-7. 3	Moderate.
A-6(8) to A-7-6(12)	95-100	85-95	50-70	0. 2-0. 63	0. 16	6. 6-7. 3	Moderate.
A-6(5-10)	95-100	95-100	50-75	0. 63-2. 0	0. 18	6. 6-7. 3	Moderate.
A-2-4(0)	100	95-100	10-35	2. 0-6. 3	0. 06	5. 6-6. 0	Low to none.
A-2-4	100	95-100	10-30	>6. 3	0. 02	5. 6-6. 0	None.
A-2-4 or A-3	100	90-100	8-20	>6. 3	0. 02	5. 6-6. 5	None.
A-6(10)	------------	100	95-100	0. 63-2. 0	0. 18	5. 1-6. 0	Moderate.
A-7-6(10-20)	------------	100	95-100	0. 2-0. 63	0. 20	5. 6-6. 5	High.
A-7-6(12-18)	------------	100	95-100	0. 63-2. 0	0. 18	6. 1-7. 3	Moderate to high.
A-7-6(13-18)	------------	100	95-100	0. 2-0. 63	0. 20-0. 24	5. 6-6. 5	High.
A-7-6(20)	------------	100	95-100	0. 2-0. 63	0. 19-0. 21	6. 1-7. 3	High.
A-7-6(12-18)	------------	100	95-100	0. 63-2. 0	0. 17-0. 20	6. 6-7. 8	High.
A-4(8) to A-6(10)	------------	100	95-100	0. 63-2. 0	0. 20	5. 6-6. 0	Moderate.
A-7-6(16-18)	------------	100	95-100	0. 05-0. 20	0. 18	5. 6-6. 5	High.
A-7-6(16-18)	------------	100	95-100	0. 05-0. 20	0. 18	6. 6-7. 3	High.
A-6(8-12)	------------	100	95-100	0. 63-2. 0	0. 20	5. 6-6. 0	Moderate.
A-6(8-10)	------------	100	95-100	0. 63-2. 0	0. 18	5. 1-5. 5	Moderate to low.
A-7-6(14-18)	------------	100	95-100	0. 2-0. 63	0. 19	5. 6-7. 3	Moderate to high.
A-6(6-10)	100	95-100	90-100	0. 63-2. 0	0. 20	7. 4-7. 8	Moderate.
A-7-6(20)	------------	100	95-100	<0. 05	0. 18	6. 1-6. 5	High.
A-7-6(17-20)	------------	100	95-100	0. 05-0. 20	0. 18	6. 6-7. 3	High.
A-7-6(16-18)	------------	100	95-100	0. 2-0. 63	0. 17	5. 6-6. 5	High.
A-7-6(20)	------------	100	95-100	<0. 05	0. 18	6. 1-6. 5	High.
A-7-6(17-20)	------------	100	95-100	0. 05-0. 20	0. 18	6. 6-7. 3	High.
A-4(8) to A-6(10)	------------	100	80-100	0. 63-2. 0	0. 20	5. 6-6. 0	Moderate.
A-6(8) to A-7-6(14)	------------	100	75-95	0. 63-2. 0	0. 18	5. 6-6. 0	Moderate.
A-7-6(15-20)	------------	100	95-100	0. 2-0. 63	0. 20	6. 1-7. 3	High.
A-7-6(18-20)	------------	100	95-100	0. 05-0. 20	0. 18	6. 1-6. 5	High.
A-7-6(16-20)	------------	100	95-100	0. 05-0. 20	0. 18	6. 1-6. 5	High.
A-6(6-10)	100	95-100	90-100	0. 63-2. 0	0. 20	7. 4-7. 8	Moderate.
A-7-6(15-20)	------------	100	95-100	0. 2-0. 63	0. 20	6. 1-6. 5	High.
A-7-6(18-20)	------------	100	95-100	0. 05-0. 2	0. 18	6. 1-6. 5	High.

[2] Seasonally wet because of seepage from more permeable, higher lying soil derived from loess.

TABLE 5.—*Engineering*

Soil series and map symbol	Suitability as source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Adair: AaC2, AaD2, AdD3, AhE2, AhE3. (For interpretations of Shelby soils in mapping units AhE2 and AhE3, refer to the Shelby series.)	Poor	Very poor in subsoil: large volume change; highly elastic; fair in substratum: easily compacted to high density.	Rolling topography; seepage can be expected seasonally in cut; difficult to vegetate.	Low compressibility; uneven consolidation; often seepy and wet; high shrink-swell potential.	Very slow permeability when compacted; easily compacted.
Alluvial land: Al, Am (For interpretations of Nodaway soil in mapping unit Am, refer to the Nodaway series.)	Variable	Good to poor: each site should be investigated.	Nearly level topography; subject to frequent flooding; high water table.	Frequent flooding; high water table.	Variable soil properties; not suitable.
Amana: An, Ao	Good	Fair to poor: low bearing capacity; poor workability; narrow range of moisture content in which soil can be compacted satisfactorily; difficult to compact.	Nearly level topography; seasonal high water table; subject to flooding; surface layer moderately high in organic-matter content; poor foundation for high fills.	Flooding likely; high compressibility; low bearing capacity.	Suitable sites unlikely; level topography; fluctuating water table.
Boone: BoE	Very poor	Good: sandstone bedrock at a depth of about 2 feet; limited amount of borrow available.	Steep topography; material easily eroded; good borrow potential; low plasticity; sandstone bedrock at depth of about 2 feet.	Sandstone bedrock at depth of about 2 feet.	Sandstone bedrock at depth of about 2 feet; not suitable.
Chelsea: CaE	Poor	Good: low shrink-swell potential; good workability unless fines are less than 15 percent of soil; lacks stability under wheel loads except when damp.	Sloping topography; highly erodible; difficult to vegetate; loose sand may hinder hauling operations; seepage may occur in deep cuts.	Low compressibility; fair to good shear strength; deep to water table; rapid consolidation; cuts may slump and flow if excavations are below water table.	Material too porous to hold water.
Chequest: Cb, Cc	Poor	Poor to unsuitable: high volume change; low bearing capacity when wet; difficult to compact to high density; high compressibility.	Nearly level topography; low borrow potential; high water table; subject to flooding; surface layer high in organic-matter content; not suitable for high fills.	Subject to high volume change; high compressibility; poor shear strength; high water table; low bearing capacity.	Subject to flooding; underlain by stratified materials at depth of 6 feet or more; fairly suitable for dugout ponds.

interpretations of the soils

Soil features affecting—Continued					
Farm ponds—Con. Embankment	Septic tank disposal field	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Impervious material; fair to good stability; moderate to high shrink-swell potential; good for impervious cores; easily compacted to high density.	Very slow permeability.	Wet because of seepage; interceptor tile placed above the seepage areas are helpful.	Very slow permeability; subject to erosion; poor for farming.	Subsoil unfavorable for crop growth; exposed subsoil difficult to vegetate; terrace channels likely to be seepy and wet.	Low fertility; tile needed in many waterways to control seepage.
Variable soil properties; not used for embankment because of landscape position.	Subject to frequent flooding; frequent high water table.	Adequate outlets are difficult to establish in many places; land leveling needed; flood protection needed.	Subject to frequent flooding; variable soil properties; poor for farming.	Not needed because of topography.	Not needed because of topography.
Low stability when wet; high compressibility; fair to poor compaction characteristics; poor resistance to piping.	Seasonal high water table; subject to flooding, especially in spring.	Tile drainage suitable; surface drainage needed in some places; flood protection needed.	High available water holding capacity; medium intake rate; some areas need drainage and flood protection.	Not needed because of topography.	Not needed because of topography.
Highly pervious material; susceptible to piping; erodible; not suitable.	Slopes commonly exceed 15 percent; cemented sandstone near depth of 2 feet.	Not needed	Low available water holding capacity; poor for farming.	Erodible; low fertility; sandstone bedrock near depth of 2 feet.	Erodible; difficult to vegetate; low fertility.
Highly erodible; low shrink-swell potential; poor resistance to piping; seepage rate high.	Poor filtering material; will permit unfiltered sewage to travel long distances; suitable in sparsely populated areas or in places where wells are not located nearby; slopes commonly over 10 percent.	Not needed	Low available water holding capacity; rapid permeability; poor for farming.	Highly erodible; difficult to build and maintain terrace ridges and channels.	Highly erodible; low available water holding capacity; difficult to vegetate.
Fair stability; poor compaction except at optimum moisture; high shrink-swell potential.	Subject to flooding; slow permeability; seasonal high water table.	Tile drains function satisfactorily; outlets difficult to obtain in some places.	High available water holding capacity; needs drainage.	Properly placed diversions to control local runoff reduce wetness in some areas.	Not needed because of topography

TABLE 5.—*Engineering interpre-*

Soil series and map symbol	Suitability as source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Clarinda: CdC2, CdD2	Very poor to not suitable.	Unsuitable: highly elastic; high volume change; low bearing capacity when wet; difficult to compact properly.	Rolling topography; low borrow potential; seepage often occurs in cuts; surface layer high in organic-matter content.	Poor shear strength; medium to low bearing capacity; high shrink-swell potential; uneven consolidation.	Very slow permeability where compacted.
Clinton: ClB, ClC, ClC2, ClD, ClD2, ClE2, CmC2, CnC3, CnD3, CnE3.	Fair: low in organic-matter content.	Poor: poor shear strength; medium bearing capacity; moderate to high shrink-swell potential; narrow range of moisture within which soil can be compacted satisfactorily.	Rolling topography; high moisture content in deep cuts likely; low borrow potential; uniform silty material.	Poor shear strength; medium bearing capacity; moderate compressibility, but uniform consolidation.	Slow permeability where compacted; low seepage rate; good sites normally available; soils on benches are underlain by stratified material at depths of 6 to 12 feet in some places and do not hold water.
Colo: Co, Cs, CsB, CtB (For interpretations of Ely soil in mapping unit CtB, refer to the Ely series.)	Fair to good	Very poor: low bearing capacity; poor shear strength; seasonal high water table; high compressibility; high in organic-matter content to depth of about 3 feet or more.	Nearly level topography; seasonal high water table; generally subject to some flooding; poor foundation for high fills.	Seasonal high water table; subject to flooding in most places; high compressibility with uneven consolidation.	High organic-matter content; some areas suitable for dugout ponds; material stratified at depth of 6 feet or below in some places.
Dickinson: DhB, DlC2, DlD2. (For interpretations of Sparta soils in all these mapping units and for Ladoga soils in mapping units DlC2 and DlD2, refer to the Sparta and Ladoga series, respectively.)	Fair to good	Good: high bearing capacity; stable under wheel loads when damp; very low compressibility; small volume change.	Nearly level and rolling topography; good borrow potential; good workability except where fines are less than 15 percent of soil; high moisture content in some deep cuts.	Low compressibility; fair shear strength; high bearing capacity; may flow if saturated.	Material too porous to hold water.
Dunbarton: DuE3	Poor	Poor: high shrink-swell potential; high volume change; easily compacted; limestone below depth of about 2 feet; good if crushed.	Rolling topography; plastic when wet; some seepage; fragmented limestone below depth of 2 feet.	Upper 2 feet has high shrink-swell potential; poor shear strength; limestone bedrock below depth of 2 feet.	Fragmented limestone below depth of 2 feet; too porous to hold water.

tations of the soils—Continued

Soil features affecting—Continued					
Farm ponds—Con.	Septic tank disposal field	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Embankment					
Fair stability on flat slopes; high volume change; moderate compressibility; high expansion potential.	Very slow permeability; seasonal high water table.	Properly placed interceptor tile helps control seepage in some areas.	Slow intake rate; very slow permeability; poor for farming.	Very low fertility; difficult to vegetate.	Difficult to vegetate; topdressing needed; seepage difficult to control.
Fair stability; compaction poor above optimum moisture and fair at or below; moderate to high expansion potential.	Moderately slow permeability.	Not needed	Moderate intake rate; high available water holding capacity; erosion control needed.	Erodible cuts should be held to a minimum to prevent exposure of less productive subsoil.	Tile needed along side to prevent seepage.
High organic-matter content in top 3 feet or more; poor embankment foundation; moderate to high expansion potential.	Seasonal high water table; generally subject to some degree of flooding; moderately slow permeability.	Moderately slow permeability; tile drains function satisfactorily; outlets difficult to obtain in places; may need flood protection.	Medium intake rate; high available water holding capacity; needs artificial drainage in many places; normally subject to some degree of flooding.	Not needed because of topography.	Tile drains needed to keep waterways dry; vegetation easily established.
Fair stability; pervious when compacted; low volume change on wetting; susceptible to piping.	Poor filtering material; will permit unfiltered sewage to travel long distances; suitable if in sparsely populated areas or if wells are not nearby.	Not needed	Low available water holding capacity; needs frequent water application.	Sandy subsoil; difficult to vegetate; erodible cuts should be held to a minimum.	Highly erodible; difficult to vegetate.
Upper 2 feet has adequate strength and stability; high expansion potential and good compaction at or near optimum moisture; difficult to work; unsuited below depth of 2 feet because of limestone fragments.	Slow permeability in upper 2 feet; permeable in fragmented limestone.	Not needed	Low available water holding capacity; slow intake rate because of clayey subsoil; subject to runoff and erosion; poor for farming.	Difficult to vegetate; low fertility; needs topdressing with topsoil; bedrock may interfere with construction.	Clayey subsoil; difficult to vegetate; low fertility; bedrock may interfere with construction.

TABLE 5.—*Engineering interpre-*

Soil series and map symbol	Suitability as source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Ely: ElB	Good	Poor: moderate to high volume change; difficult to compact; low bearing capacity.	Nearly level to sloping topography; high organic-matter content; seasonal high water table; subject to local flooding or overflow of short duration.	Low bearing capacity; moderate to high compressibility; subject to short local floods.	Difficult to compact—reservoir bottom should be scarified and compacted.
Gara: GaD2, GaE, GaE2, GaF2, GrE3.	Fair to poor	Good: medium to high bearing capacity; good workability and compaction; easily compacted to high density.	Rolling topography; variable materials in cuts; some cuts may be seepy; good borrow potential.	Medium to high bearing capacity; good shear strength; low compressibility; uneven consolidation.	Slow permeability when compacted; good sites usually available.
Givin: GsA, GtA	Fair	Very poor: low bearing capacity when wet; poor shear strength; large volume change; difficult to compact to high density; narrow range of moisture content within which compaction is satisfactory.	Nearly level topography; seasonal high water table; low borrow potential.	Moderate to high compressibility; uniform consolidation; seasonal high water table; saturation may cause loss of cohesion resulting in settlement.	Suitable sites unlikely.
Gosport: GuE2	Poor	Very poor to unsuitable: low bearing capacity; poor shear strength; high shrink-swell potential; high compressibility; laminated shale within depth of 2 feet.	Rolling topography; very poor to unsuitable for borrow; often wet and seepy.	Poor shear strength; low bearing capacity; high compressibility and shrink-swell potential; seasonal high water table; dangerous expansion potential if initially dry.	Slow permeability; occasionally mixed with sandstone which may need a seal blanket.
Humeston: Hu	Fair	Very poor: high in elasticity; large volume change; low bearing capacity when wet; poor shear strength.	Level topography; low borrow potential; subject to flooding; seasonal high water table; moderately high organic-matter content; poor foundation for high fills.	Subject to flooding; highly expansive if wide fluctuation in moisture content; high water table.	Suitable sites unlikely; dugouts possible; slow permeability when compacted; subject to flooding; underlain by stratified material at depth of 6 feet or more.

tations of the soils—Continued

Soil features affecting—Continued					
Farm ponds—Con. Embankment	Septic tank disposal field	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Adequate strength and stability; moderate to high expansion potential; good compaction at or near optimum moisture.	Seasonal high water table.	Wet because of seepage; interceptor tile needed.	Moderate intake rate; high available water holding capacity; good for farming.	Terraces not needed; diversion terraces needed for protection from overflow.	Tile needed to prevent seepage and to establish vegetation.
Adequate stability; easily compacted to high density; good workability; good for cores.	Moderately slow permeability.	Interceptor tile needed to control seepage at loess-till contact line.	Rapid runoff; high available water holding capacity; erosion control practices needed.	Suitable on slopes less than 12 percent; cuts should be held to a minimum because of the less productive subsoil.	Tile needed to keep waterways dry in order to establish vegetation.
Low stability when wet; moderate to high shrink-swell potential; high compressibility; narrow range of moisture for satisfactory compaction.	Needs tile drains; seasonal high water table; moderately slow permeability.	Tile drains satisfactory; in depression surface drains are beneficial.	High available water holding capacity; requires tile drainage before irrigation in some places.	Not needed because of topography.	Not needed because of topography.
Clayey subsoil and shaley substratum have high shrink-swell potential and may tend to creep in embankments; slow permeability; high shrink-swell potential.	Very slow permeability in the subsoil and substratum; slope.	Not needed	Steep slopes; poor for farming.	Clayey, infertile subsoil; poor for farming.	Very difficult to vegetate; clayey subsoil low to very low in fertility and strongly acid.
Fair stability; slow permeability; high shrink-swell potential; high compressibility.	Subject to flooding; high water table; slow permeability.	Protection from stream overflow needed; tile may not drain all areas satisfactorily; use surface drains where depressional; outlets difficult to establish in some places.	High available water holding capacity; susceptible to stream overflow; adequate drainage difficult to obtain.	Terraces not needed; properly placed diversions can help to reduce local ponding and to improve drainage.	Not needed because of topography.

TABLE 5.—*Engineering interpre-*

Soil series and map symbol	Suitability as source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Judson: JcC	Excellent	Poor: high organic-matter content in upper 2 to 3 feet; low bearing capacity when wet; difficult to compact to high density.	Runoff; seepy areas in some places; low borrow potential; high organic-matter content; nearly level to gently sloping topography.	High compressibility; medium bearing capacity; fair shear strength; subject to local runoff from higher elevations.	Difficult to compact; reservoir bottoms should be scarified and compacted; some seepage.
Keomah: KeA	Fair: low in organic-matter content.	Poor: high shrink-swell potential; low bearing capacity when wet; narrow moisture range within which compaction is satisfactory.	Nearly level; seasonal high water table; poor workability and compaction when wet; low borrow potential.	Medium bearing capacity; moderate to high compressibility; uniform consolidation; seasonal high water table.	Nearly level topography; suitable sites unlikely.
Keswick: KsD, KsD2, KwD3, KxE3, KyE2. (For interpretations of Lindley soils in mapping units KxE3 and KyE2, refer to the Lindley series.)	Poor	Very poor to depth of about 4 feet, good in substratum: elastic; high shrink-swell potential; highly dense material; good workability and compaction in substratum.	Rolling topography; may have seepage in some cuts; highly susceptible to frost action when sand pockets occur; difficult to establish vegetative cover on slopes.	Low compressibility; high bearing capacity below depth of 4 feet; highly expansive if subject to wide fluctuations in moisture.	Slow permeability; low seepage.
Koszta: KzA	Fair	Poor: poor compaction above optimum moisture; large volume change and low bearing capacity when wet.	Nearly level topography; seasonal high water table; low borrow potential.	Medium to high compressibility; low bearing capacity; seasonal high water table; saturation may cause soil to settle; may liquefy when wet.	Poor compaction—reservoir bottom should be scarified and compacted; suited to dugout ponds; may be stratified below depth of 4 feet or more.
Ladoga: LaB, LaC, LaC2, LaD, LaD2, LbB, LdC3, LdD3.	Fair: thin layer containing organic matter.	Poor: medium bearing capacity; poor shear strength; moderate to high shrink-swell potential; difficult to compact to high density; narrow range of moisture content within which compaction is satisfactory.	Rolling topography; high moisture content in some deep cuts; low borrow potential.	Medium bearing capacity; poor shear strength; moderate compressibility; uniform consolidation.	Uniform material; slow permeability when compacted; soils on benches may be underlain with stratified material at depth of 6 to 12 feet; deep cuts on benches may have low water holding potential.

tations of the soils—Continued

Soil features affecting—Continued					
Farm ponds—Con.	Septic tank disposal field	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Embankment					
Fair stability; high compressibility; moderate expansion potential; difficult to compact except at optimum moisture.	Periodic overflow may cause damage to filter field.	Most areas do not need tile drains; interceptor tile needed in some seepy areas.	High available water holding capacity; moderate intake rate; good for farming.	Terraces generally not needed; diversions help to protect from local overflow.	Soil properties favorable; tile helpful in controlling seepage in places.
Fair stability; high shrink-swell potential; difficult to compact to high density when wet; high compressibility.	Moderately slow permeability; seasonal high water table.	Tile drains satisfactory; some areas do not require tile.	Moderate intake rate; moderately slow permeability; high available water holding capacity.	Not needed because of topography.	Not needed because of topography.
Fair to good stability; moderate to high shrink-swell potential; good compaction at or near optimum moisture; low compressibility; good for core material.	Slow to very slow permeability; seasonally wet and seepy.	Wet because of seepage; interceptor tile needed at loess-till contact line.	High available water holding capacity; slow to very slow permeability; subject to runoff and erosion; poor for farming.	Subsoil unfavorable for crop growth; terrace channel may be wet and seepy; cuts should be held to a minimum; slope exceeds 12 percent in many places.	Tile needed to control seepage and to establish vegetation.
Fair stability; medium to high compressibility; moderate to high shrink-swell potential; poor compaction.	Seasonal high water table.	Tile drains satisfactory; not all areas require tile.	Moderate intake rate; high available water holding capacity.	Not needed because of topography.	Generally not needed because of topography.
Low stability when wet; poor compaction above optimum moisture; slow permeability when compacted; moderate to high shrink-swell potential.	Moderately slow permeability.	Generally not needed.	Moderate intake rate; high available water holding capacity; erosion control practices needed.	Slight limitations on slopes less than 12 percent.	Soil properties favorable; tile generally not needed to control seepage.

TABLE 5.—*Engineering interpre-*

Soil series and map symbol	Suitability as source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Lamoni: LmC2, LmD2, LnD3, LoE2. (For interpretations of Shelby soil in mapping unit LoE2, refer to the Shelby series.)	Poor	Poor: elastic; high volume change; difficult to compact properly.	Rolling topography; seasonal high water table; moderately high in organic-matter content; often high moisture content in cuts; poor borrow potential.	Very expansive when wide fluctuations in moisture content; medium bearing capacity; uneven consolidation.	Very slow permeability when compacted.
Lamont: LpC2, LpD2, LpE2, LpF2. (For interpretations of Clinton soil and Chelsea soil in these mapping units, refer to the Clinton and Chelsea series, respectively.)	Poor	Good: little or no volume change; good workability and compaction except where fines are less than 15 percent of soil; lacks stability in substratum except when damp.	Rolling topography; high moisture content in some cuts; good borrow potential; highly erodible where exposed in embankments; loose sand may hinder hauling operations.	Very low compressibility; low volume change with moisture; good shear strength; may liquefy slowly if excavated when saturated.	Material too porous to hold water.
Lindley: LrD2, LrE, LrE2, LrF, LrF2, LrG, LsE3.	Poor	Good: medium to high bearing capacity; low compressibility; easily compacted to high density; moderate volume change.	Rolling to steep topography; good source of borrow; some cuts may be seepy; low organic-matter content in surface layer.	Medium to high bearing capacity; fair to good shear strength; low compressibility; uneven consolidation.	Slow permeability; good sites likely.
Mahaska: MaA, MhA	Good	Unsuitable: low bearing capacity; fair shear strength; moderate to high shrink-swell potential; highly compressible; elastic; difficult to compact properly.	Nearly level topography; high organic-matter content in upper part; seasonal high water table; low borrow potential.	High compressibility; uniform consolidation; low bearing capacity; fair shear strength; expansive if subject to wide fluctuation in moisture content.	Suitable sites unlikely; slow permeability when compacted; uniform material; sites on benches may be underlain with stratified materials at depth of 10 to 15 feet; deep cuts on benches may not hold water.
Martinsburg: MrB, MrC	Good	Fair to poor: low bearing capacity; very narrow range of moisture content within which soil can be compacted well; compaction difficult.	Low borrow potential; subject to flash flooding; subject to frost heave and loss of bearing capacity on thawing.	Subject to occasional flooding; high compressibility; may liquefy and flow if saturated; low bearing capacity.	Compaction difficult; seepage.
Nira: NgB, NmB (For interpretations of Givin soil in mapping unit NgB and of Mahaska soil in mapping unit NmB, refer to the Givin and Mahaska series, respectively.)	Fair to good	Very poor: large volume change; very low bearing capacity when wet; difficult to compact to high density.	Rolling topography; low borrow potential; highly susceptible to frost action; cuts often have high moisture content.	High compressibility; subject to frost heave and subsequent loss of strength on thawing; may flow if excavated when saturated.	Commonly occurs too high on landscape for suitable sites; slow permeability when compacted.

tations of the soils—Continued

Soil features affecting—Continued					
Farm ponds—Con.	Septic tank disposal field	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Embankment					
Fair stability on flat slopes; impervious when compacted; suitable for cores; high expansion potential.	Very slow permeability; seasonally seepy and wet.	Properly placed interceptor tile needed to control seepage in some areas.	Slow intake rate and very slow permeability; poor for farming.	Very low fertility in subsoil; difficult to vegetate.	Difficult to vegetate where subsoil is exposed; topdressing needed in many places.
Fair stability; small volume change; susceptible to piping; difficult to vegetate embankments; highly erodible.	Substratum is poor filtering material and allows unfiltered sewage to travel long distances.	Not needed----------	Rapid intake rate; low available water holding capacity.	Loose sandy substratum may hinder construction; difficult to maintain ridges and channels; sandy subsoil infertile.	Highly erodible; difficult to establish and maintain vegetation.
Good stability; easily compacted to high density; usable for core material; slow permeability when compacted; good workability.	Slopes often exceed 10 percent; moderately slow permeability in subsoil.	Generally not needed; interceptor tile may be useful if placed at the loess-till contact line to control seepy spots.	Subject to high rate of runoff and erosion; low natural fertility; high available water holding capacity.	Slopes irregular and steep in places; subsoil low in fertility in many places.	Difficult to vegetate; tile needed to control seepage in places.
Fair stability; high shrink-swell potential; poor compaction above optimum moisture; high compressibility.	Seasonal high water table; moderately slow permeability.	Tile drains satisfactory; not all areas need tile.	Moderate intake rate; high available water holding capacity; good for farming.	Not needed because of topography.	Not needed because of topography.
Loss of stability when wet; very narrow range of moisture content for compaction; high compressibility; poor resistance to piping.	Subject to flash flooding, which may damage filter field.	Not needed----------	High available water holding capacity; needs protection from local runoff in places.	Well suited to diversion terraces.	Soil properties favorable.
Low stability when wet; poor workability above or below optimum moisture; high compressibility.	Seasonally wet and seepy.	Properly placed interceptor tile needed to control seepage; tile not needed in places.	High available water holding capacity; erodible.	Soil properties favorable; terraces may increase seepage unless carefully placed and constructed.	Tile drainage needed in places to control seepage.

TABLE 5.—*Engineering interpre-*

Soil series and map symbol	Suitability as source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Nodaway: No, Ns, NwB (For interpretations of Martinsburg soil in mapping unit NwB, refer to Martinsburg series.)	Excellent	Very poor: low bearing capacity when wet; moderate volume change; difficult to compact to high density.	Nearly level topography; subject to occasional overflow; high organic-matter content below depth of about 3 feet in places; seasonal high water table; poor foundation for high fills.	High compressibility; subject to flooding; low bearing capacity.	Good sites unlikely; some seepage.
Olmitz: OlC	Good	Poor: high in organic-matter content to depth of 2 to 3 feet; medium to low bearing capacity; moderate shrink-swell potential.	Gently sloping topography; high in organic-matter content to depth of 2 or 3 feet; poor source of embankment material; subject to flash floods.	Medium to low bearing capacity; fair shear strength; medium compressibility; moderate shrink-swell potential; deep cuts are seepy in some places.	Only a few areas can be used for reservoirs because of position on the landscape; slow permeability when compacted.
Otley: OtB, OtC, OtC2; OtD2.	Good	Poor: large volume change; medium bearing capacity; moderate compressibility; difficult to compact to high density.	Rolling topography; surface layer moderate to high in organic-matter content; high moisture content in some deep cuts; cuts easily vegetated.	Moderate compressibility; uniform consolidation; medium bearing capacity; expansive if subject to wide fluctuations in moisture content.	Uniform material to depth of 6 to 12 feet; slow permeability when compacted.
Radford: Ra, ReB (For interpretations of Ely soil in mapping unit ReB, refer to the Ely series.)	Excellent in upper 2 feet, fair below.	Very poor: low bearing capacity; moderate volume change when wet; upper 2 feet difficult to compact to high density; seasonal high water table; high compressibility and high content of organic matter below a depth of 2 feet.	Nearly level topography; subject to occasional overflow; layer high in organic-matter content below depth of about 2 feet; poor foundation for high fills.	High compressibility; subject to flooding; low bearing capacity; uneven consolidation.	Compaction difficult; some seepage can be expected.
Rubio: Ru	Poor	Very poor: large volume change; medium bearing capacity; highly elastic; satisfactory compaction difficult.	Level topography; low borrow potential; seasonal high water table; subject to ponding; areas generally small.	Poor shear strength; tendency for dangerous expansion if initially dry; seasonal high water table.	Suitable sites unlikely; occurs on high upland divides with very low potential watershed; very slow permeability.

tations of the soils—Continued

Soil features affecting—Continued					
Farm ponds—Con. Embankment	Septic tank disposal field	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Low stability; high moisture content; poor compaction above optimum moisture; suitable for shell but not for core; moderate expansion potential; poor resistance to piping.	Subject to fequent flooding.	Most areas do not need tile; need overflow protection in some places.	Moderate intake rate; high available water holding capacity; subject to flooding; seasonal high water table.	Not needed because of topography.	Soil properties favorable; tile needed to control seepage in places.
High in organic-matter content to depth of 2 or 3 feet; fair stability; fair to poor workability and compaction; medium to high compressibility.	Moderate permeability; periodic overflow may cause damage to filter fields.	Not needed	High available water holding capacity; medium intake rate; subject to erosion and gullying.	Diversions placed upslope protect soil from local runoff.	Easily vegetated.
Fair stability; poor compaction above optimum moisture; moderate to high shrink-swell potential; moderate compressibility.	Moderately slow permeability.	Not needed	Moderate intake rate; high available water holding capacity; erosion control practices needed.	Soil properties favorable; slight limitation on slopes of less than 12 percent.	Vegetation easily established; tile needed to keep waterways dry.
Fair to low stability in upper 2 feet when moisture content is high, very poor stability in lower part; poor compaction above optimum moisture; moderate expansion potential; poor resistance to piping; suitable for shell but not for core.	Subject to frequent flooding.	Most areas do not need tile; overflow protection needed.	Moderate intake rate; slow permeability in the subsoil; high available water holding capacity; subject to flooding.	Not needed because of topography.	Tile may be needed to control seepage in order to establish vegetation; soil properties favorable.
Low stability when wet; impervious; high expansion potential; difficult to compact properly.	Very slow permeability; seasonal high water table.	Tile may not drain all areas; surface drainage needed to remove ponded water.	High available water holding capacity; very slow permeability; difficult to obtain satisfactory drainage.	Not needed	Not needed.

TABLE 5.—*Engineering interpre-*

Soil series and map symbol	Suitability as source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Shelby: ShE2	Fair	Good: medium to high bearing capacity; low compressibility; good workability and compaction; easily compacted to high density.	Rolling topography; variable material in cuts; some deep cuts may be seepy; good borrow potential.	Medium to high bearing capacity; good shear strength; low compressibility; uneven consolidation.	Slow permeability when compacted; good sites generally available.
Sogn: SoF	Poor: shallow to bedrock.	Excellent in substratum: limestone bedrock.	Steep topography; cuts and fills needed; good borrow potential; limestone hard and levelbedded.	Bedrock at a depth of about 15 inches.	15 inches or less to fractured bedrock.
Sparta	Poor	Good: low shrink-swell potential; high bearing capacity; good workability unless fines are less than 15 percent of soil; no volume change; lacks stability under wheel loads except when soil is damp.	Rolling topography; highly erodible; seepage possible in some deep cuts; difficult to vegetate; loose sand may hinder hauling operations; good borrow potential.	Low compressibility; good shear strength; rapid consolidation; low volume change on wetting; may liquefy during excavation and slump if wet.	Material too porous to hold water.
Sperry: Sp	Fair to poor: upper 10 inches high in organic-matter content.	Unsuitable: low bearing capacity; high volume change; difficult to compact properly; moderate to high compressibility.	Depressional topography; high water table; moderately high organic-matter content in surface layer; individual areas 1 to 2 acres in size; low borrow potential.	Low bearing capacity; moderate to high compressibility; uniform consolidation; high water table.	Suitable areas unlikely; slow permeability when compacted; occurs on high upland divides.
Taintor: Ta, Tb	Fair	Unsuitable: elastic; medium bearing capacity; poor shear strength; high shrink-swell potential; difficult to compact properly.	Nearly level topography; high organic-matter content in upper 1 to 2 feet; seasonal high water table; low borrow potential.	Moderate compressibility; medium bearing capacity; uniform consolidation; subject to large volume change.	Suitable sites unlikely; slow permeability when compacted; uniform material to depth of 10 to 15 feet; soils on benches are underlain with stratified material at a depth of 10 feet or below.
Tuskeego: Tu	Poor	Very poor: highly elastic; large volume change; low bearing capacity; difficult to compact properly.	Level topography; low borrow potential; seasonal high water table; subject to ponding; size of soil areas generally small.	Low bearing capacity; poor shear strength; subject to dangerous expansion if initially dry; seasonal high water table.	Slow permeability; may be underlain with stratified material at depth of 5 feet or below; may be suitable for dug-out ponds.

tations of the soils—Continued

Soil features affecting—Continued					
Farm ponds—Con. Embankment	Septic tank disposal field	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Adequate stability; easily compacted to high density; good workability; suitable for cores.	Moderately slow permeability.	Interceptor tile may be helpful to control seepage at the loess-till contact line.	High available water holding capacity; erosion control practices needed.	Cuts should be held to a minimum because the subsoil is low in fertility.	Tile needed to keep waterways dry.
15 inches or less to bedrock.	15 inches or less to limestone bedrock.	Not needed	Very low available water holding capacity; very shallow to bedrock; poor for farming.	Limestone bedrock at depth of 15 inches or less.	Bedrock may interfere with construction.
Seepage rate high; high stability; highly erodible; small volume change; poor resistance to piping.	Rapid permeability; poor filtering material permits unfiltered sewage to travel long distances; suitable in sparsely populated areas and in areas that lack wells.	Not needed	Low available water holding capacity; rapid permeability; rapid intake rate.	Highly erodible; difficult to build and maintain terrace ridges and channels; vegetative cover difficult to establish where subsoil is exposed.	Highly erodible; low available water holding capacity; difficult to vegetate.
Low stability when wet; moderate to high shrink-swell potential; poor workability when wet; moderate to high compressibility.	High water table; slow permeability.	Tile may not drain all areas; surface drains needed to remove ponded water.	High available water holding capacity; needs drainage before irrigation.	Not needed because of topography.	Not needed because of topography.
Semi-impervious to impervious when compacted; fair stability; poor compaction when wet; high shrink-swell potential; poor workability above optimum moisture.	Seasonal high water table.	Tile drains satisfactory if properly spaced.	High available water holding capacity; moderately slow intake rate; needs drainage before irrigation; good for farming.	Not needed because of topography.	Not needed because of topography.
Low stability when wet; impervious; high volume change with moisture; moderate to high compressibility.	Seasonal high water table; very slow permeability.	Tile lines may not drain all areas; surface drainage needed to remove ponded water.	High available water holding capacity; very slow permeability; difficult to obtain satisfactory drainage.	Terraces not needed because of topography; diversions properly placed upslope help to control local runoff and reduce wetness.	Not needed because of topography.

TABLE 5.—*Engineering interpre-*

Soil series and map symbol	Suitability as source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Vesser: Ve, VeB	Good to fair	Fair to poor: low bearing capacity; moderate to high shrink-swell potential; difficult to compact to high density; narrow range of moisture content within which compaction is satisfactory.	Nearly level topography; subject to flooding; seasonal high water table; low borrow potential; surface layer high in organic-matter content; poor foundation for high fills.	High compressibility; subject to short floods; seasonal high water table; uneven consolidation.	Slow permeability when compacted; good sites unlikely; some areas may be satisfactory for dugout ponds; may be underlain with stratified material at depth of 5 feet or below.
Wabash: Wa, Wc	Poor	Unsuitable: low bearing capacity; very high volume change; elastic; difficut to compact; narrow range of moisture content within which compaction is satisfactory.	Level topography; surface layer high in organic-matter content; high water table; subject to flooding; low borrow potential.	Low bearing capacity; poor shear strength; medium to high compressibility; subject to very dangerous expansion if initially dry; high water table.	Suitable sites unlikely; may be suitable for dugout ponds; subject to flooding; very slow permeability.
Watkins: WkA, WkB	Good	Poor to fair: moderately high volume change; medium bearing capacity; difficult to compact to high density.	Nearly level to gently sloping topography; low borrow potential; surface layer high in organic-matter content.	High compressibility; medium bearing capacity; if initially wet, subject to high expansion potential.	Suitable sites unlikely; reservoir bottom should be scarified and compacted; some areas too porous to hold water; may be stratified below depth of 5 feet.
Zook: Zk, Zo	Poor	Unsuitable: extremely high volume change; low bearing capacity; highly elastic; difficult to compact properly.	Level to depressional topography; surface layer high in organic-matter content; high water table; low borrow potential.	Low bearing capacity; poor shear strength; medium to high compressibility; high water table; subject to dangerous shrinkage on drying.	Suitable sites unlikely; level to depressional topography; subject to flooding; very slow permeability; suitable for dugouts; may be stratified below depth of 5 feet.

tations of the soils—Continued

Soil features affecting—Continued					
Farm ponds—Con.: Embankment	Septic tank disposal field	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Fair to poor stability; moderate to high shrink-swell potential; poor compaction when wet; some areas may be susceptible to piping.	Subject to flooding; seasonal high water table.	Tile drains satisfactory where outlets can be obtained.	Moderate water intake rate; high available water holding capacity; tile drainage needed before irrigation.	Diversions properly placed are beneficial in preventing local runoff and siltation.	Generally not needed; tile needed along side of drainageways to prevent seepage.
Impervious; fair stability on flat slopes; poor compaction and workability; high shrink-swell potential.	Very slow permeability; high water table.	Surface ditches needed along dominant slope.	Water intake rate varies with amount of vertical cracks; high available water holding capacity; very slow permeability; difficult to obtain suitable drainage.	Not needed because of topography.	Not needed because of topography.
Fair stability; moderate to high shrink-swell potential; high compressibility.	Moderate permeability.	Not needed	Moderate intake rate; high available water holding capacity; good for farming.	Terrace construction difficult in many places because of shape and length of slope; diversions properly placed upslope protect soil from runoff and siltation.	Soil properties favorable, but waterways generally not needed because of topography.
Impervious; low stability when wet; poor compaction and workability; high shrink-swell potential.	Slow permeability; subject to flooding.	Tile lines may not drain all places; proper spacing and depth of tile are important; most areas need flood protection.	Intake rate varies with amount of vertical cracking; high available water holding capacity; needs drainage before irrigation.	Terraces not needed because of topography; diversions properly placed improve drainage and reduce siltation.	Not needed because of topography.

TABLE 6.—*Engineering*

Soil name and location	Parent material	Iowa report No.	Depth	Moisture-density [2]	
				Maximum dry density	Optimum moisture
			Inches	*Lb. per cu. ft.*	*Percent*
Clinton silt loam: 72 feet west and 125 feet south of northeast corner of SE¼SE¼, section 7, T. 74 N., R. 12 W. (Modal).	Wisconsin loess	AAD3-12811	4-9	102	18
		AAD3-12812	20-27	100	21
		AAD3-12813	58-72	101	20
Mahaska silty clay loam: 965 feet south and 278 feet east of northwest corner of NE¼, section 34, T. 77 N., R. 10 W.	Wisconsin loess	AAD2-282	0-7	93	21
		AAD2-283	24-30	95	24
		AAD2-284	51-61	102	17
Otley silty clay loam: 154 feet east and 481 feet south of northwest corner of SW¼NE¼, section 34, T. 77 N., R. 10 W.	Wisconsin loess	AAD2-285	0-12	94	18
		AAD2-286	17-32	95	23
		AAD2-287	46-73	103	18
Taintor silty clay loam: 385 feet north and 51 feet east of southwest corner of SE¼SW¼, section 27, T. 77 N., R. 10 W.	Wisconsin loess	AAD2-279	0-6	91	25
		AAD2-280	22-28	100	21
		AAD2-281	40-50	105	17

[1] Tests performed by the Iowa State Highway Commission in accordance with standard procedures of the American Association of State Highway Officials (AASHO).
[2] Based on AASHO Designation T 99-57, Method A (*1*).
[3] Mechanical analyses according to the AASHO Designation T 88-57 (*1*). Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material,

Reaction is the degree of acidity or alkalinity, expressed as a pH value. The pH of a neutral soil is 7.0, of an acid soil is less than 7.0, and of an alkaline soil is more than 7.0.

Shrink-swell potential indicates the change in volume that occurs with a change in moisture content. Those soil materials rated high normally are undesirable for use in engineering, because the increase in volume that occurs when dry soil is wetted normally is accompanied by a loss in bearing capacity. In general, soils classed as CH and A-7 have a high shrink-swell potential. Clean sand and gravel (single grain structure) and soils having small amounts of nonplastic to slightly plastic fines have a low shrink-swell potential.

Engineering interpretations of the soils

In table 5 the soils in Keokuk County are rated according to their suitability for topsoil and road fill, and features are named that affect suitability for location of highways, for building farm ponds, for establishing drainage and irrigation systems, terraces and diversions, and waterways.

Suitability as a source of sand or gravel is not shown in table 5, because none of the soils in the county are suitable as sources of gravel and most of them do not have enough sand that is suitable for construction purposes. The Boone soil, however, has poorly graded sand and is fairly well suited to well suited as construction material; the Chelsea and Sparta soils have poorly graded sand that is suited; and the substratum of the Lamont soil is poorly graded sand that is suited.

Soil features affecting highway work [3]

Many of the soils in Keokuk County formed in loess that overlies glacial till. The loess ranges from as much as 15 feet on the nearly level upland divides to a thin layer in the more sloping dissected areas. In many places where slopes are more than 15 percent, the loess is very thin or absent and the glacial till crops out on the surface.

The glacial till in Keokuk County has a relatively high in-place density. It is relatively stable at any moisture content, and it can be compacted readily to high density. The textural composition varies, but when the material is dry, there are enough fines and coarse material to provide a firm riding surface that has little rebound after loading. The glacial till has good bearing capacity when compacted to maximum practical density, but loses this bearing capacity when moisture is absorbed.

The Mahaska, Taintor, Keomah, Rubio, Givin, and other soils that were derived from loess in nearly level areas have a fine-textured B horizon, or subsoil, that is classified A-7 (CL or CH). These soils have high group index numbers. The surface layer of the Mahaska and Taintor soils is high in content of organic matter and is

[3] By DONALD A. ANDERSON, soil engineer, Iowa State Highway Commission.

test data [1]

Mechanical analysis [3]						Liquid limit	Plasticity index	Classification	
Percentage passing sieve—		Percentage smaller than—						AASHO [4]	Unified [5]
No. 40 (0.42 mm.)	No. 200 (0.074mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
						Percent			
100	98	87	55	22	13	28	7	A-4(8)	ML-CL
100	99	94	70	45	36	50	29	A-7-6(18)	CL
----------	100	89	62	33	26	43	23	A-7-6(14)	CL
100	98	92	70	38	29	43	18	A-7-6(12)	ML-CL
100	99	94	73	50	42	60	34	A-7-6(20)	CH
----------	100	95	68	39	33	46	26	A-7-6(16)	CL
100	99	92	66	37	28	43	19	A-7-6(12)	CL
----------	100	94	71	45	38	52	26	A-7-6(17)	CH
----------	100	94	74	37	31	44	23	A-7-6(14)	CL
100	99	92	72	44	36	56	29	A-7-6(19)	CH
100	99	95	75	48	40	62	39	A-7-6(20)	CH
----------	100	92	65	37	31	49	29	A-7-6(17)	CL

including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soil.

[4] Based on AASHO designation M 145-49 (*1*).

[5] Based on the Unified Soil Classification System (*19*). Soil Conservation Service and Bureau of Public Roads have agreed to consider that all soils having plasticity indexes within 2 points from A-line are to be given a borderline classification.

difficult to compact to high density. The subsoil is plastic silty clay or silty clay loam that expands readily and does not make a good upper subgrade. Other soils derived from loess are the more sloping Clinton, Ladoga, and Otley soils. These soils have a plastic silty clay loam subsoil. They are classified A-7 (CL or CH) and have fairly high group indexes. Loessal soils erode readily where runoff is concentrated. Sodding, paving, or check dams may be needed in gutters and ditches so as to control excessive erosion.

In these soils derived from loess, the seasonal water table generally is above the contact of the loess and the highly weathered glacial till, which is called gumbotil. In the more nearly level areas a perched water table occurs within 1 to 3 feet of the surface. In these soils, the density of the loess in place is fairly low and the moisture content is high. The content of moisture may cause instability in embankment unless it is controlled enough to permit the soil to be compacted to high density.

Underlying the loess in the more level areas is weathered Kansan till that is fairly uniform and of poor quality for road construction work. In the more sloping parts of the county, this highly weathered glacial till is the present land surface. The Clarinda, Lamoni, Adair, and Keswick soils formed from the highly weathered glacial till. These soils have a plastic, highly weathered silty clay or clay subsoil and are classified as A-7-6 (15-20). This clay material is not stable enough to be used for a highway subgrade, and it should not be used in parts of fills within 5 feet of a finished grade. If this clay material occurs at grade in roadcuts, it should be replaced with a backfill of less weathered glacial till, such as that in the Shelby, Gara, and Lindley soils.

Below these clayey layers is a heterogeneous Kansan till that is classified primarily A-6 (CL). This till crops out on the lower part of slopes and is the parent material of Gara, Lindley, and Shelby soils. If this till occurs in or along grading projects, it generally is placed in the upper subgrade in unstable areas. Pockets and lenses of sand commonly are interspersed throughout the till and in many places are water bearing. Frost heaving is likely if the road grade is only a few feet above these deposits of sand and the deposits are overlain by loess or loamy till. Frost heaving can be prevented by draining these deposits, by replacing the soil above them with a backfill of coarse-textured material or with good glacial clay till.

The soils on bottom lands developed from recent alluvium. Of these soils, the Colo, Ely, Judson, Zook, Humeston, Wabash, Amana, and Vesser have a thick surface layer that is high in organic-matter content and does not compact well under an embankment load. They have low density in place and a high moisture content. Consequently, these soils should be carefully analyzed if an embankment is to be more than 15 feet high. Roadways through the bottom lands should be constructed on a continuous embankment that is above the level of floods.

The bedrock in Keokuk County is so far below the

glacial and loess deposits that it plays no major part in development of the soils. Beds of limestone, sandstone, and shale crop out mainly along the Skunk River and its tributaries. The Sogn and Dunbarton soils developed in the areas of limestone. The beds of sandstone are discontinuous across Keokuk County and crop out in only a few places along the Skunk River. The Boone soils occur in the sandstone outcrops. The shale occurs principally in the northwest quarter of the county, though there are a few small areas in other parts. The shale contains thin lenses of sandstone, limestone, and coal, and the soil above it slides in some places. Shale is exposed only in the strongly dissected areas of Gosport soils along the Skunk River, the South Skunk River, and their tributaries. The limestone is crushed and used to surface the secondary roads throughout the county.

Formation and Classification of Soils

This section presents the outstanding morphologic characteristics of the soils of Keokuk County and relates them to the factors of soil formation. The two systems of soil classification now in use are explained and the soil series are classified. Physical data are given for selected soil profiles.

Factors of Soil Formation

Soil is produced when soil-processes act on materials deposited or accumulated by geologic forces. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent materials; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of soil development have acted on the soil material.

Climate and vegetation, chiefly vegetation, are active factors in soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it into a natural body with genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed and, in extreme instances, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. It may be much or little, but some time is always required for horizon differentiation. Usually, a long time is required for the development of distinct horizons.

These five factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one unless conditions are specified for the other four. Many of the processes of soil development are not fully known.

Parent material

Most of the soils in Keokuk County have developed from glacial till, (ice-laid material), loess (windblown material), and alluvium (water-laid material). Local loess and eolian sands are of minor importance along the Skunk and English Rivers. In Keokuk County parent material does not affect the development of soils as much as the other factors unless the parent material is pure quartz sand. Sand dominates in the formation of the soil and determines the kind of profile that forms.

Glacial till.—The major Pleistocene deposits of pre-Wisconsin age in the county are Nebraskan and Kansan drift (*11*). The Nebraskan drift is exposed only in some of the steeper, more dissected areas of the county. The Kansan drift is identifiable throughout the county, and on steep slopes it forms an extensive part of the landscape (*8*). Glacial till consists of coarse fragments in a loam and clay loam matrix. The steeper soils in the county formed from till that is leached and oxidized to a depth of 3 to 6 feet. Below this is a layer of unleached oxidized till several feet thick. It grades to unleached glacial till that has not been oxidized. These strata can be seen in many deep road cuts in the county.

Soils developed on the Kansan till plain during the Yarmouth and Sangamon interglacial ages. This was before the loess was deposited. In nearly level areas, beveling was slight. Beveling is the planing by geologic erosion of the outcropping edges of strata. In time the soils were strongly weathered and had formed a gray, clayey subsoil called gumbotil (*3*, *4*). It is several feet thick on stable divides and is very slowly permeable. A widespread erosion surface was cut below the Yarmouth-Sangamon paleosol into Kansan till and older deposits. This surface generally is characterized by a stone line and is overlain by pedisediment (*8*, *9*) (fig. 14). A paleosol formed in the pedisediment stone line and in the underlying till.

***Figure 14.*—A stone line on the Late Sangamon erosional surface covered with 5 feet of loess.**

Geologic erosion has removed the loess from many slopes and has exposed the strongly weathered paleosols. In some places the paleosols have been beveled or truncated, and only the lower part of the strongly weathered material remains. In other places erosion has removed all of the paleosols and has exposed till that is only slightly weathered.

The Clarinda soils formed where the strongly weathered gray paleosols crop out. The Lamoni soils formed where the paleosols are partly truncated. Where the less strongly weathered, reddish paleosols crop out, the Adair and Keswick soils formed. The Shelby, Gara, and Lindley soils formed on slightly weathered Kansan till. These soils, the youngest on glacial till in Keokuk County, developed after loess was deposited during the Late Wisconsin time *(8)*.

Loess.—Loess of Wisconsin age covers much of Keokuk County, particularly on the most stable landscape, and is the most extensive parent material in the county. The loess ranges from about 10 to 12 feet in thickness on the stable upland divides, but it is thinner on the steeper side slopes (7). It consists of accumulated particles of silt and clay that have been deposited by wind. Variations in the soils are related to their distance from the source of loess. Figure 15 shows that differences in the loess vary significantly with topography.[4] All the loess was deoxidized and leached in a typical level upland divide. On this type of loess-covered divide, the Sperry, Taintor, Keomah, Givin, and Rubio soils formed. The Mahaska soils may have developed from both oxidized loess and deoxidized loess, because iron segregations and gray colors can be traced into a browner upper part of the profile. Similar iron segregations and gray colors merge with the gleyed upper part of the profile in Taintor and Sperry soils. According to Dideriksen, the loess was deoxidized before the soils formed, and the weathering zones represent differences in parent material.

In the more sloping soils on convex slopes of the upland divides, the upper part of the loess was oxidized and leached and the lower part was deoxidized and leached. Below the weathering zones, the basal loess part is of Farmdale age.

The deoxidized and leached weathering zone over the Yarmouth-Sangamon paleosols occurs throughout Keokuk County, except where the loess is very thin or absent on steep side slopes. The deoxidized and leached zone is related to the paleosol and is not necessarily related to the thickness of the loess. The surface layer and subsoil of the Otley, Ladoga, and Clinton soils developed predominantly from oxidized and leached loess. The Nira soils have formed mainly from deoxidized and leached loess.

[4] DIDERIKSEN, R. I. 1966. SOIL-LANDSCAPE RELATIONSHIPS OF THE MAHASKA TOPOSEQUENCE. Unpublished Master of Science thesis in Iowa State University Library, Ames, Iowa.

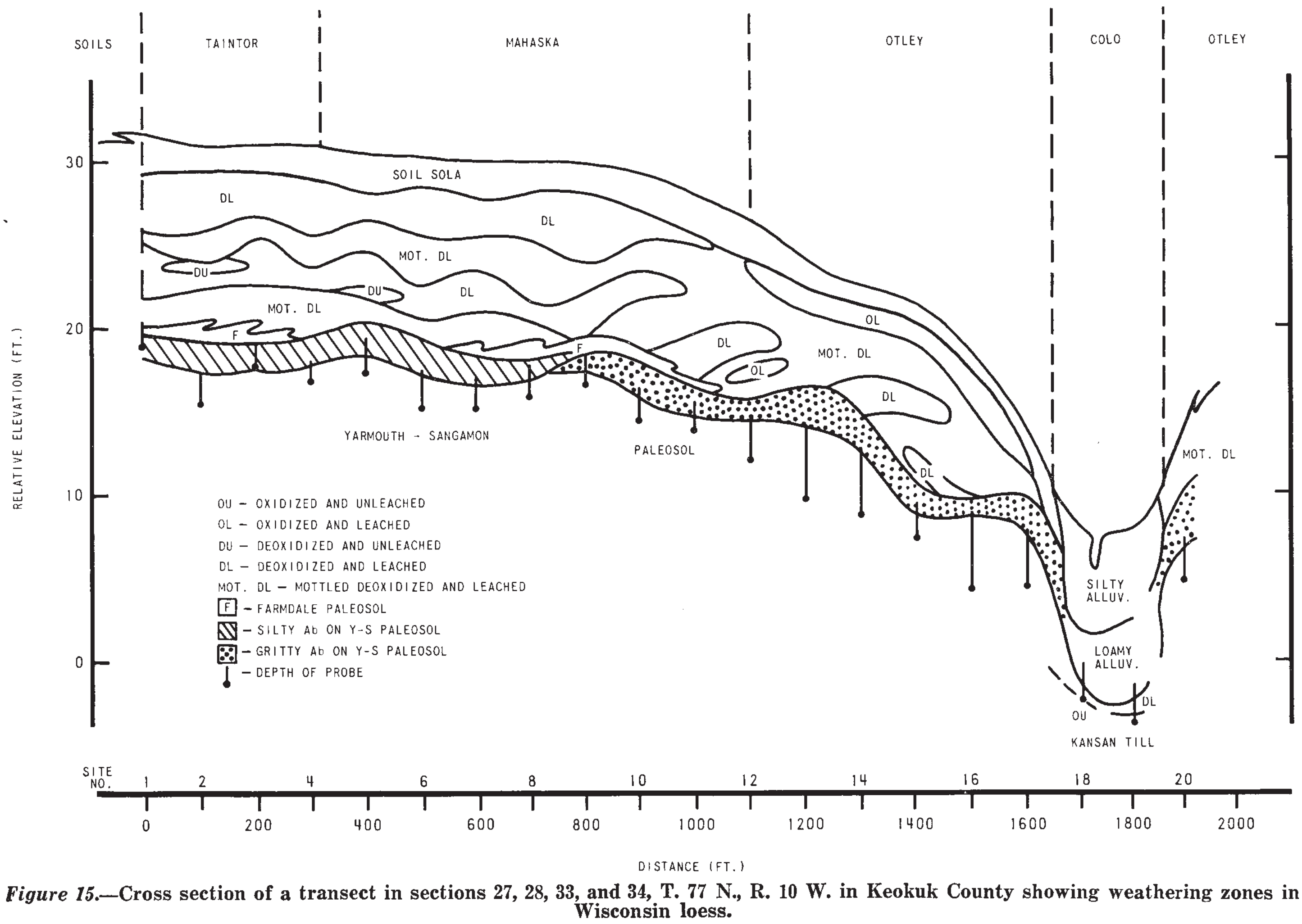

***Figure 15.*—Cross section of a transect in sections 27, 28, 33, and 34, T. 77 N., R. 10 W. in Keokuk County showing weathering zones in Wisconsin loess.**

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Alluvium.—Alluvium consists of sediments that have been removed and laid down by water. As they move, these sediments are sorted to some extent, but they are as well sorted as loess in only a few places. Also, alluvium does not have the wide range of particle sizes that occurs in glacial drift. Alluvium is silt and clay, silt and sand, or sand and gravel. The coarse sand and gravel generally occur only in the pre-Sangamon alluvial sediment in high stream benches, and in most places in Keokuk County, are buried beneath several feet of loess. Because the alluvium in the county was derived from loess and glacial drift, it consists mostly of a mixture of silt and clay or silt and sand. Where sediments have accumulated at the foot of the slope on which they originated, the materials are called local alluvium. Alluvial sediments are the parent material of the soils on flood plains, on terraces, and along drainageways.

If a river overflows and water spreads over the flood plain, coarse-textured materials such as sand are deposited first. Sand commonly is deposited in low ridges, called natural levees, parallel to and near the channel. As the floodwater continues to spread, it moves more slowly and deposits the finer textured sediments such as silt. After the flood has passed, the finest particles, or the clay, settle from the water that is left standing in the lowest part of the flood plain.

This pattern of sedimentation can be seen on flood plains along the English and Skunk Rivers. Near the channels, or within the present meander belt, are recent alluvial soils, such as the Nodaway, and Alluvial land. Alluvial land consists of some sandbars next to the channel and of various amounts of sand, silt, and clay. The Nodaway soils consist mainly of stratified silty material. Where floods do not spill over the natural levees, some finer textured material was deposited. On bottom lands, away from the meander belt, the Amana, Vesser, and similar soils developed. These soils consist mainly of silt and partly of sand and clay. Beyond these soils, commonly as much as half a mile from the present channel, the finer textured Colo and Chequest soils occur. Farthest from the channel are the Wabash, Zook, and Humeston soils, which contain a higher percentage of clay than the Amana and Nodaway soils.

The Colo, Nodaway, and Radford soils occur along many of the smaller streams and upland drainageways throughout the county. Where the texture differs, so do the chemicals and minerals. Except for the medium acid to strongly acid Amana, Vesser, and Chequest soils, the soils are mostly free of carbonates and slightly acid.

The soils on terraces or second bottoms also consist of alluvium and vary in texture. The Watkins, Tuskeego, and Koszta soils are moderately fine textured. They developed in alluvium that contained little sand, but some of the benches are underlain with sand below a depth of 4 feet.

The Ely, Judson, and Martinsburg are the principal soils that formed at the base of upland slopes or from local alluvium. They are widely distributed throughout the county and make up a large percentage of the soils formed in alluvium.

Eolian sand.—Wind-deposited sand is not extensive in Keokuk County. Deposits occur along the North Skunk, South Skunk, Skunk, and English Rivers. Most of the deposits are immediately adjacent to these major streams on the south side of the channel. The eolian sand is mostly of quartz, which resists weathering and has not been altered much since it was deposited. The Sparta and Chelsea soils developed in eolian sand and can be distinguished by their high content of fine and very fine sand and their low content of silt and clay. The Lamont and Dickinson soils developed mainly in wind-deposited sandy material, but they contain larger amounts of silt and clay than the Sparta or Chelsea soils.

Limestone bedrock.—All of Keokuk County is underlain by limestone bedrock, but in most places it is covered to great depths by loess and glacial till. The only place that the limestone crops out is on steep slopes along the Skunk River and its tributaries. The Sogn and Dunbarton soils are shallow to limestone and make up a very small percentage of the county.

Sandstone bedrock.—The beds of sandstone are discontinuous across Keokuk County. These beds crop out from a few steep soils along the Skunk River (fig. 16).

***Figure 16.*—A roadcut through sandstone. The Boone soils developed in weathered sandstone.**

Shale bedrock.—Shale is the parent material of the Gosport soils. Shale can be distinguished from the loess by its high content of clay and, when moist, by its soapy feel. The shale in the county contains thin lenses of sandstone, limestone, and in some areas, coal. The shale is exposed only on steep slopes adjacent to the Skunk River and its tributaries.

Climate

The soils of Keokuk County have been developing under a midcontinental climate. Summers are warm, occasionally dry, and windy, and winters are cold and dry (*6*). Rainfall is moderate. It is thought that the soils on nearly level upland areas of the county are about 14,000 to 16,000 years old (*10*) and that the climate was cool and moist from 25,000 to 5,000 years ago. From 5,000 years ago to the present time the climate was warmer and subhumid to humid.

The influence of the general climate of the county is modified by local conditions in or near the developing

soil. For example, soils on south-facing slopes formed under a microclimate that is warmer and drier than the average climate of nearby areas. The depressions and wide divides have a high water table during part of the year, but available data indicate that the depth to the water table has changed. In his studies of the Mahaska toposequence, Dideriksen found that the downward movement of clay had been impeded by a water table that was higher or more permanent than the one that exists at present. This is supported by the fact that the poorly drained soils have a shallower depth to clay maximum than do the nearly level, moderately well drained soils.

Climate also is closely related to topography. As landscapes differ, the influence of climate on soil development changes.

Plant and animal life

Plant and animal life, especially plant life, are important factors in soil formation. Studies of groups of soils in eastern, central, and southern Iowa show that significant differences in soils were caused by variations in vegetation (*20*). *Corliss*[5] reported that differences in soils in southeastern Iowa were related to vegetation and topography. Studies of the soils in Keokuk County show that from 25,000 years ago to about 6,500 years ago the predominant vegetation was forest, and from 6,500 years ago to the present the climate favored prairie grasses (*10, 18*).

Soil formation really begins with the coming of vegetation. Organic matter, or humus, imparts a dark color to the surface soil. Because grasses have many roots and tops that decay on or in the soil, soils formed under prairie vegetation have a thick, dark-colored surface layer. Prairie vegetation was dominant in Keokuk County on the undulating and gently rolling soils on broad uplands. In contrast, soils formed under trees have a thinner, lighter colored surface layer because the amount of organic matter, derived principally from leaves, is much less than that derived from tall prairie grasses. Forest vegetation dominates the broken uplands along the rivers and larger creeks throughout Keokuk County.

Evidence indicates that vegetation shifted during soil development in areas bordering the prairie and forest areas. The Givin, Ladoga, and Gara soils reflect the influence of both trees and grass.

Relief

Relief is an important cause of differences among soils. It indirectly influences soil development through its effect on drainage. In his studies of soil properties by landscape units in northeastern Keokuk County, Dideriksen concluded that soils in landscape units have distinct properties, and that the differences in soil properties are equally great or greater by landscape units than by natural drainage classes.

In Keokuk County, the relief ranges from broad, level upland divides and rolling to steep side slopes to broad, nearly level bottom lands. Because very little rainfall runs off, the broad upland divides have seasonal high water tables. The bottoms frequently are flooded and also have seasonal high water tables. On stronger slopes, much of the rainfall runs off. In Keokuk County, the percentage of clay is highest in depressional areas and lowest on side slopes; also, the greatest depth to maximum clay was below wide interfluves and the shallowest was in depressions. The ratio of clay in the subsoil to that in the surface layer is highest in soils in depressional areas and lowest on wide divides. Depth to the most acid part of the profile is shallowest in depressions and on wide divides, but there is little difference in depth on other landscape units.

On the Shelby, Gara, Lindley, and similar soils that have a wide range of slopes and landscapes, the depth to carbonates is shallower where slopes are the steepest and convex, or on the most unstable portion of the landscape.

In places throughout Keokuk County, changes in topography have resulted in the exposure of weathered material. In the loess areas, deoxidized loess is exposed. The Nira soils developed from deoxidized and leached loess. At lower elevations, paleosols that formed from material laid down in the Yarmouth-Sangamon and Late Sangamon periods of glaciation are exposed. The Clarinda, Lamoni, Adair, and Keswick soils developed from these paleosols.

Time

The length of time required for a soil to develop affects the kind of soil that forms. An older or more strongly developed soil shows well-defined genetic horizons. A less well developed soil shows only weakly developed horizons.

Organic matter collected by Dideriksen at the basal increment of loess on a wide divide in Keokuk County was determined to be 24,640±1,100 radio-carbon years old. The major part of the loess deposits is stratigraphically younger. Since the major part of the loess is deposited in strata over the Farmdale Formation, the loess must be post-Farmdale in age. The geologically uneroded or only slightly modified loessal soils on uplands in southeastern Iowa are less than 14,000 years old (*10*).

No precise ages can be assigned to landscape surfaces in Keokuk County, but relative ages can be determined (*15*). If the major loess surface is 14,000 to 16,000 years old, the surface of the loess on wide divides is similar in age or younger. Side slopes that cut or bevel these wide divides must have a surface layer that is younger, or less than 16,000 years old. Since much or all of the alluvial sediment in the upland drainageways came from adjacent upland slopes, the maximum age of the side slopes in these drainageways should be the same as the lower increment of alluvial sediment in the valleys. The minimum age of the side slopes should equal the age of the surface of the alluvium. Applying this line of reasoning, the Otley and Nira soils are younger than the adjoining Taintor and Mahaska soils, and the Clinton and Ladoga soils are younger than the Given, Keomah, and Rubio soils.

The Clarinda, Lamoni, Adair, and Keswick soils are among the oldest soils in the county (*10*). These soils formed from Kansan till that began to weather in Yarmouth-Sangamon and Late Sangamon time. The Shelby, Lindley, and Gara soils formed from Kansan

[5] CORLISS, J.F. 1958. GENESIS OF LOESS-DERIVED SOILS IN SOUTHEASTERN IOWA. Unpublished Ph.D. thesis, Iowa State University Library, Ames, Iowa.

till that was exposed in the Wisconsin stage and in Recent time. These soils are younger than those on the stable upland because they are not mantled with loess. They are younger than or at least no older than the most stable Otley, Mahaska, Ladoga, Clinton, or Givin soils.

Man's influence on the soil

Important changes take place in the soil when it is cultivated. Some of these changes have little effect on soil productivity; others have drastic effect.

Changes caused by water erosion generally are the most apparent. On many of the cultivated soils in the county, particularly the gently rolling to hilly ones, part or all of the original surface has been lost through sheet erosion. In some places shallow to deep gullies have formed.

In many continuously cultivated fields, the granular structure that was apparent when the grassland was undisturbed is no longer present. In these fields the surface layer tends to bake and harden when it dries. Fine-textured soils that have been plowed when too wet tend to puddle and are less permeable than similar soils in undisturbed areas.

Man has done much to increase productivity of the soil and to reclaim areas not suitable for crops. He has made large areas of bottom lands suitable for cultivation by digging drainage ditches and constructing diversions at the foot of slopes. Through the use of commercial fertilizers, man has counteracted deficiencies in plant nutrients and has made some soils more productive than they were in their natural state.

Classification of Soils

Soils are classified so that we may more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us understand their behavior and their response to manipulation. First through classification and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

Thus, in classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and applied in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. They are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*2*) and later revised (*14*). The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. This system is under continual study. Therefore, readers interested in development of this system should search the latest literature available (*17, 12*). In table 7 some of the classes in the current system are given for each soil series represented in the county. The classes in the current system are briefly defined in the following paragraphs.

ORDER. The ten soil orders recognized are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Utisols, Oxisols, and Histosols. The properties used to differentiate these soil orders are those that tend to give broad climatic groupings of soils. Two exceptions, the Entisols and Histosols, occur in many different climates.

The four orders found in Keokuk County are Inceptisols, Mollisols, Alfisols, and Entisols. Inceptisols, based on the Latin word *inceptum* meaning beginning, are young soils in which genetic horizons definitely have started to form but in which eluviation and illuviation are not pronounced. The Gosport soils are the only Inceptisols in Keokuk County.

Mollisols have dark-colored surface horizons in which base saturation is high and the content of organic matter is at least 1 percent. These soils have genetic subsurface horizons that vary in degree of development. In Keokuk County this order includes soils previously classified as Brunizems, Humic Gleys, and Planosols.

Alfisols have clay-enriched B horizons that are high in base saturation. In Keokuk County this order includes soils formerly classified as Gray-Brown Podzolic soils that intergrade to Brunizems.

Entisols do not have genetic horizons or have only the beginnings of such horizons. The surface layer of these soils is darkened by organic matter. The Entisols in Keokuk County were formerly classified as Alluvial soils.

SUBORDER. Each order is subdivided into suborders, primarily on the basis of those characteristics that seem to produce classes with the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders mainly reflect either the presence or absence of wetness, or soil differences resulting from climate or vegetation. The names of suborders have two syllables, and the last syllable indicates the order. For example, in Udolls, *Ud* is from the Latin word meaning humid and *oll* is from Mollisol.

GREAT GROUPS. Soil suborders are separated into great groups on the basis of uniformity in kind and sequence of major soil horizons and features. The horizons used to make such separations are those in which clay, iron, or humus has accumulated or those in which pans interfere with the growth of roots or movement of water. The features used are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown in a separate column in table 7, because it is the last word in the name of the subgroup.

SUBORDERS. Great groups are divided into subgroups, one representing the central (typic) segment of the group and others, called intergrades, that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups also may be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of the subgroups are derived by placing one or more adjectives before the name

TABLE 7.—*Soil series classified according to the current system of classification*

Series	Current system		
	Family	Subgroup	Order
Adair	Fine, montmorillonitic, mesic	Aquic, Argiudolls	Mollisols.
Amana	Fine-silty, mixed, mesic	Aquic Hapludolls	Mollisols.
Boone	Sandy, siliceous, acid, mesic	Typic Quartzipsamments	Entisols.
Chelsea	Sandy, siliceous, acid, mesic	Alfic Udipsamments	Entisols.
Chequest	Fine, montmorillonitic, noncalcareous, mesic	Typic Haplaquolls	Mollisols.
Clarinda	Fine, montmorillonitic, noncalcareous, mesic, sloping	Vertic Argiaquolls	Mollisols.
Clinton	Fine, montmorillonitic, mesic	Typic Hapludalfs	Alfisols.
Colo	Fine-silty, mixed, noncalcareous, mesic	Cumulic Haplaquolls	Mollisols.
Dickinson	Coarse-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Dunbarton	Clayey, montmorillonitic, mesic	Lithic Hapludalfs	Alfisols.
Ely	Fine-silty, mixed, mesic	Aquic Cumulic Hapludolls	Mollisols.
Gara	Fine-loamy, mixed, mesic	Mollic Hapludalfs	Alfisols.
Givin	Fine, montmorillonitic, mesic	Udollic Ochraqualfs	Alfisols.
Gosport	Fine, illitic, mesic	Typic Dystrochrepts	Inceptisols.
Humeston	Fine, montmorillonitic, mesic	Argiaquic Argialbolls	Mollisols.
Judson	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Keomah	Fine, montmorillonitic, mesic	Aeric Ochraqualfs	Alfisols.
Keswick	Fine, montmorillonitic, mesic	Aquic Hapludalfs	Alfisols.
Koszta	Fine-silty, mixed, mesic	Udollic Ochraqualfs	Alfisols.
Ladoga	Fine, montmorillonitic, mesic	Mollic Hapludalfs	Alfisols.
Lamoni	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Lamont	Coarse-loamy, siliceous, mesic	Typic Hapludalfs	Alfisols.
Lindley	Fine-loamy, mixed, mesic	Typic Hapludalfs	Alfisols.
Mahaska	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Martinsburg	Fine-silty, mixed, mesic	Typic Hapludalfs	Alfisols.
Nira	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Nodaway	Fine-silty, mixed, nonacid, mesic	Typic Udifluvents	Entisols.
Olmitz	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Otley	Fine, montmorillonitic, mesic	Typic Argiudolls	Mollisols.
Radford	Fine-silty, mixed, mesic	Fluventic Hapludolls	Mollisols.
Rubio	Fine, montmorillonitic, mesic	Mollic Albaqualfs	Alfisols.
Shelby	Fine-loamy, mixed, mesic	Typic Argiudolls	Mollisols.
Sogn	Loamy, mixed, mesic	Lithic Haplustolls	Mollisols.
Sparta	Sandy, siliceous, mesic	Entic Hapludolls	Mollisols.
Sperry	Fine, montmorillonitic, mesic	Typic Argialbolls	Mollisols.
Taintor	Fine, montmorillonitic, noncalcareous, mesic	Typic Argiaquolls	Mollisols.
Tuskeego	Fine, montmorillonitic, mesic	Moltlic Ochraqualfs	Alfisols.
Vesser	Fine-silty, mixed, mesic	Argiaquic Argialbolls	Mollisols.
Wabash	Fine, montmorillonitic, mesic	Vertic Haplaquolls	Mollisols.
Watkins	Fine-silty, mixed, mesic	Mollic Hapludalfs	Alfisols.
Zook	Fine, montmorillonitic, noncalcareous, mesic	Cumulic Haplaquolls	Mollisols.

of the great group. An example is Typic Hapludoll (a typical Hapludoll).

FAMILIES. Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. A family name precedes the subgroup name and consists of a series of adjectives descriptive of these various properties. An example is the coarse-loamy, mixed, mesic family of Typic Hapludolls.

Mechanical Analysis

All samples reported in table 8 were collected from sites carefully selected as representative of the landform for that soil. Sites were considered typical in morphological characteristics as far as could be determined from field observations.

Cores were extracted by use of Giddings power probe. Particle size analyses were run at the Iowa State University Laboratory by members of the field party. They used the pipette method described by Kilmer and Alexander (*5*). The 10-gram samples were treated with a 30 percent solution of hydrogen peroxide. Then the samples were oven dried at about 105° C for 12 hours before weighing. Sodium hexametaphosphate was added to disperse the soil, and the samples were placed in a shaker for 12 hours. Sedimentation time for clay and fine silt was determined by using the nomograph by Tanner and Jackson (*13*). The sand fraction was determined by wet sieving, and coarse silt was calculated by difference. Two standards were used in a run of 20 samples.

TABLE 8.—*Mechanical analysis data for profiles of selected soils*

[Analyses were made at Iowa State University Laboratory]

Soil type and location	Horizon	Depth	Particle size distribution: Sand (2.0–0.05 mm.)	Silt (0.05–0.02 mm.)	Silt (0.02–0.002 mm.)	Clay (less than 0.002 mm.)	Textural class
		Inches	*Percent*	*Percent*	*Percent*	*Percent*	
Amana silt loam: 1,020 feet south and 40 feet east of northwest corner of SW¼ of section 15, T. 77 N., R. 12 W.	A1	0–10	7.9	27.3	35.5	29.3	Silty clay loam.
	A3	10–18	9.2	28.2	31.4	31.2	Silty clay loam.
	B1	18–24	9.6	27.4	32.5	30.5	Silty clay loam.
	B21	24–30	10.2	28.9	31.9	29.0	Silty clay loam.
	B22	30–36	9.9	30.3	30.5	29.3	Silty clay loam.
	B23	36–41	9.8	29.6	30.3	30.3	Silty clay loam.
	B3	41–51	12.1	31.0	33.4	23.5	Silt loam.
	C1	51–65	18.2	31.3	26.2	24.3	Silt loam.
Clinton silt loam: 72 feet west and 125 feet south of northeast corner of SE¼SE¼ of section 7, T. 74 N., R. 12 W.	A1	0–2	3.2	39.6	41.3	15.9	Silt loam.
	A21	2–4	2.7	41.1	38.9	17.3	Silt loam.
	A22	4–9	2.5	37.5	41.8	18.2	Silt loam.
	A23	9–15	2.3	34.4	40.5	22.8	Silt loam.
	B21t	15–20	2.8	28.9	35.1	34.4	Silty clay loam.
	B22t	20–27	1.4	26.6	34.5	37.5	Silty clay loam.
	B23t	27–39	1.1	28.2	31.7	39.0	Silty clay loam.
	B24t	39–47	1.2	27.3	36.1	35.4	Silty clay loam.
	B31t	47–58	1.2	29.8	34.4	34.6	Silty clay loam.
	B32t	58–72	1.5	32.1	35.8	30.6	Silty clay loam.
	C	72–84	1.6	33.6	37.0	27.8	Silty clay loam.
Colo silty clay loam: 2,040 feet south and 1,390 feet west of northeast corner of section 6, T. 77 N., R. 13 W.	Ap	0–8	3.5	20.5	45.0	31.0	Silty clay loam.
	A12	8–16	3.5	25.9	42.5	27.1	Silty clay loam.
	A13	16–32	12.6	19.3	35.3	32.8	Silty clay loam.
	A3	32–42	9.0	22.9	32.9	35.2	Silty clay loam.
	B2g	42–56	19.5	10.2	33.8	36.5	Silty clay loam.
	B3	56–72	12.4	18.8	32.4	36.4	Silty clay loam.
Givin silt loam: 530 feet west and 300 feet north of NE¼SW¼ of section 24, T. 76 N., R. 11 W.	Ap	0–8	1.0	39.3	40.7	19.0	Silt loam.
	A2	8–12	2.6	30.7	43.4	23.3	Silt loam.
	B1	12–16	2.9	29.7	39.3	28.2	Silty clay loam.
	B21t	16–23	1.8	26.8	36.2	35.2	Silty clay loam.
	B22t	23–28	1.7	26.6	32.8	39.0	Silty clay loam.
		28–34	1.5	30.4	31.4	36.8	Silty clay loam.
	B23t	34–38	1.3	32.4	32.3	34.0	Silty clay loam.
		38–42	1.0	30.2	32.8	36.0	Silty clay loam.
	B3t	42–46	1.0	29.7	33.6	35.8	Silty clay loam.
		46–50	0.8	30.5	32.0	36.7	Silty clay loam.
Humeston silt loam: 1,140 feet south and 280 feet west of northeast corner of NW¼NE¼ of section 3, T. 74 N., R. 12 W.	Ap	0–6	8.3	12.9	50.3	28.5	Silty clay loam.
	A12	6–10	8.4	11.4	51.5	28.7	Silty clay loam.
	A2	10–15	8.1	12.4	55.2	24.3	Silt loam.
	B1	15–18	1.9	16.1	47.2	34.8	Silty clay loam.
	B21t	18–26	6.9	6.4	40.0	46.1	Silty clay.
	B22t	26–34	1.3	12.4	43.3	43.0	Silty clay.
	B23tg	34–50	2.3	9.3	42.8	45.6	Silty clay.
Keswick silt loam: 320 feet east and 475 feet south of northwest corner of NE¼NW¼ of section 17, T. 76 N., R. 11 W.	Ap	0–3	24.1	30.8	27.8	17.2	Silt loam.
	A2	3–9	32.4	15.2	27.0	15.4	Silt loam.
	IIB1t	9–19	28.1	13.5	18.2	40.1	Clay.
	IIB21t	19–28	22.0	7.4	8.4	62.1	Clay.
	IIB22t	28–39	38.3	12.4	12.6	36.6	Clay loam.
	IIB3t	39–52	41.4	13.1	14.5	31.0	Clay loam.
	IIC	52–64	47.8	11.5	14.2	26.5	Sandy clay loam.
Lamoni silty clay loam: 85 feet east and 20 feet north of southwest corner of NE¼SE¼ of section 22, T. 76 N., R. 10 W.	Ap	0–7	7.5	28.9	33.0	30.6	Silty clay loam.
	A3	7–11	7.6	26.5	34.8	31.1	Silty clay loam.
	B1t	11–15	8.5	42.0	19.0	30.5	Silty clay loam.
	IIB21t	15–21	13.8	16.4	24.6	45.2	Silty clay.
	IIB22t	21–29	22.9	14.8	19.7	42.6	Clay.
	IIB23t	29–38	34.7	14.1	15.2	36.0	Clay loam.
	IIB31t	38–42	36.6	17.0	13.6	33.8	Clay loam.
	IIB32	42–53	35.7	11.5	17.2	35.6	Clay loam.

TABLE 8.—*Mechanical analysis data for profiles of selected soils*—Continued

Soil type and location	Horizon	Depth	Particle size distribution				Textural class
			Sand (2.0–0.05 mm.)	Silt (0.05–0.02 mm.)	Silt (0.02–0.002 mm.)	Clay (less than 0.002 mm.)	
		Inches	*Percent*	*Percent*	*Percent*	*Percent*	
Lindley loam: 300 feet east and 100 feet south of northwest corner of NW¼SW¼ of section 24, T. 76 N., R. 11 W.	A1–A2	0–7	43. 4	20. 4	21. 4	14. 8	Loam.
	B1	7–13	46. 2	15. 5	18. 0	20. 3	Loam.
	B21t	13–19	40. 5	11. 9	14. 8	32. 8	Clay loam.
	B22t	19–26	40. 7	10. 1	11. 8	37. 4	Clay loam.
	B23t	26–33	42. 8	10. 5	12. 8	33. 9	Clay loam.
	B31t	33–41	45. 9	10. 8	12. 7	30. 6	Sandy clay loam.
	B32	41–50	48. 5	11. 3	14. 0	26. 2	Sandy clay loam.
Martinsburg silt loam: 1,300 feet east and 2,550 feet north of southwest corner of section 8, T. 75 N., R. 13 W.	Ap	0–6	8. 0	40. 2	31. 0	20. 8	Silt loam.
	A21	6–13	3. 9	36. 2	36. 3	23. 2	Silt loam.
	A22	13–20	2. 6	33. 6	42. 4	21. 4	Silt loam.
	B1t	20–27	1. 8	30. 8	39. 8	28. 2	Silty clay loam.
	B21t	27–34	1. 9	28. 2	39. 3	30. 6	Silty clay loam.
	B22t	34–41	1. 9	30. 4	33. 9	33. 8	Silty clay loam.
	B31t	41–50	1. 3	31. 9	32. 4	34. 4	Silty clay loam.
	B32t	50–57	1. 2	34. 0	33. 6	32. 4	Silty clay loam.
	B33t	57–65	1. 2	66. 0	33. 2	31. 6	Silty clay loam.
	B34t	65–70	1. 9	33. 8	33. 7	30. 6	Silty clay loam.
	B35t	70–74	1. 4	34. 3	32. 6	31. 7	Silty clay loam.
	B36t	74–87	1. 3	34. 4	35. 2	29. 1	Silty clay loam.
	C1	87–96	1. 7	32. 4	38. 8	27. 1	Silty clay loam.
Nira silty clay loam: 792 feet west and 752 feet south of road center in northeast corner of NW¼ of section 34, T. 77 N., R. 10 W.	Ap	0–7	1. 7	29. 6	34. 2	34. 5	Silty clay loam.
	A3	7–10	1. 4	27. 0	32. 8	38. 8	Silty clay loam.
	B21t	10–17	1. 3	28. 6	33. 6	36. 5	Silty clay loam.
	B22t	17–22	1. 2	27. 5	36. 1	35. 2	Silty clay loam.
	B31t	22–28	1. 2	30. 0	38. 1	30. 8	Silty clay loam.
	B32t	28–34	1. 3	33. 0	36. 1	29. 6	Silty clay loam.
	B33t	34–42	1. 6	32. 7	36. 4	29. 3	Silty clay loam.

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Glossary

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available moisture capacity. The capacity of a soil to hold water in a form available to plants. Amount of moisture held in soil between field capacity, or about one-third atmosphere of tension, and the wilting coefficient, or about 15 atmospheres of tension.

Bench terrace. A shelflike embankment of earth that has a level or nearly level top and a steep or nearly vertical downhill face, constructed along the contour of sloping land or across the slope to control runoff and erosion. The downhill face of the bench may be made of rocks or masonry, or it may be planted to vegetation.

Bottom, first. The normal flood plain of a stream; land along the stream subject to overflow.

Bottom, second. An old alluvial plain, generally flat, that borders a stream but is seldom flooded.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Complex, soil. A mapping unit consisting of different kinds of soils that occur in such small individual areas or in such an intricate pattern that they cannot be shown separately on a publishable soil map.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Diversion, or diversion terrace. A ridge of earth, generally a terrace, that is built to divert runoff from its natural course and, thus, to protect areas downslope from the effects of such runoff.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the oven-dry weight, after the gravitational, or free, water has been allowed to drain away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity.*

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Fragipan. A loamy, brittle, subsurface horizon that is very low in organic matter and clay but is rich in silt or very fine sand. The layer is seemingly cemented. When dry, it is hard or very hard and has a high bulk density in comparison with the horizon or horizons above it. When moist, the fragipan tends to rupture suddenly if pressure is applied, rather than to deform slowly. The layer is generally mottled, is slowly or very slowly permeable to water, and has few or many bleached fracture planes that form polygons. Fragipans are a few inches to several feet thick; they generally occur in the B horizon, 15 to 40 inches below the surface.

Gleyed soil. A soil in which waterlogging and lack of oxygen have caused the material in one or more horizons to be neutral gray in color. The term "gleyed" is applied to soil horizons with yellow and gray mottling caused by intermittent waterlogging.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay; sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Interfluves. The district between adjacent streams flowing in the same direction.

Leaching, soil. The removal of materials in solution by the passage of water through the soil.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state. In engineering, a high liquid limit indicates that the soil has a high content of clay and a low capacity for supporting loads.

Parent material. The weathered rock or partly weathered soil material from which soil has formed; horizon C in the soil profile.

Pedisediment. A sediment that covers a pediment rather thinly. A pediment is an erosion surface that lies at the foot of a receded slope, is underlain by rocks or sediment of the upland, is barren or mantled with alluvium, and displays a longitudinal profile, normally concave upward.

Permeability. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

pH value. A numerical means for designating relatively weak acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value alkalinity; and a lower value, acidity.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Mildy alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Site index. A numerical means of expressing the quality of a forest site that is based on the height of the dominant stand at an arbitrarily chosen age; for example, the average height attained by dominant and codominant trees in a fully stocked stand at the age of 50 years.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristics of the soil are largely confined to the solum.

Stone line. A concentration of coarse rock fragments in soils that generally represents an old weathering surface. In a cross section, the line may be one stone or more thick. The line generally overlies material that weathered in place, and it is ordinarily overlain by sediment of variable thickness.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically the part of the soil below the solum.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surplus runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

Well-graded soil. A soil or soil material consisting of particles that are well distributed over a wide range in size or diameter. Such a soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

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GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. Other information is given in tables as follows:

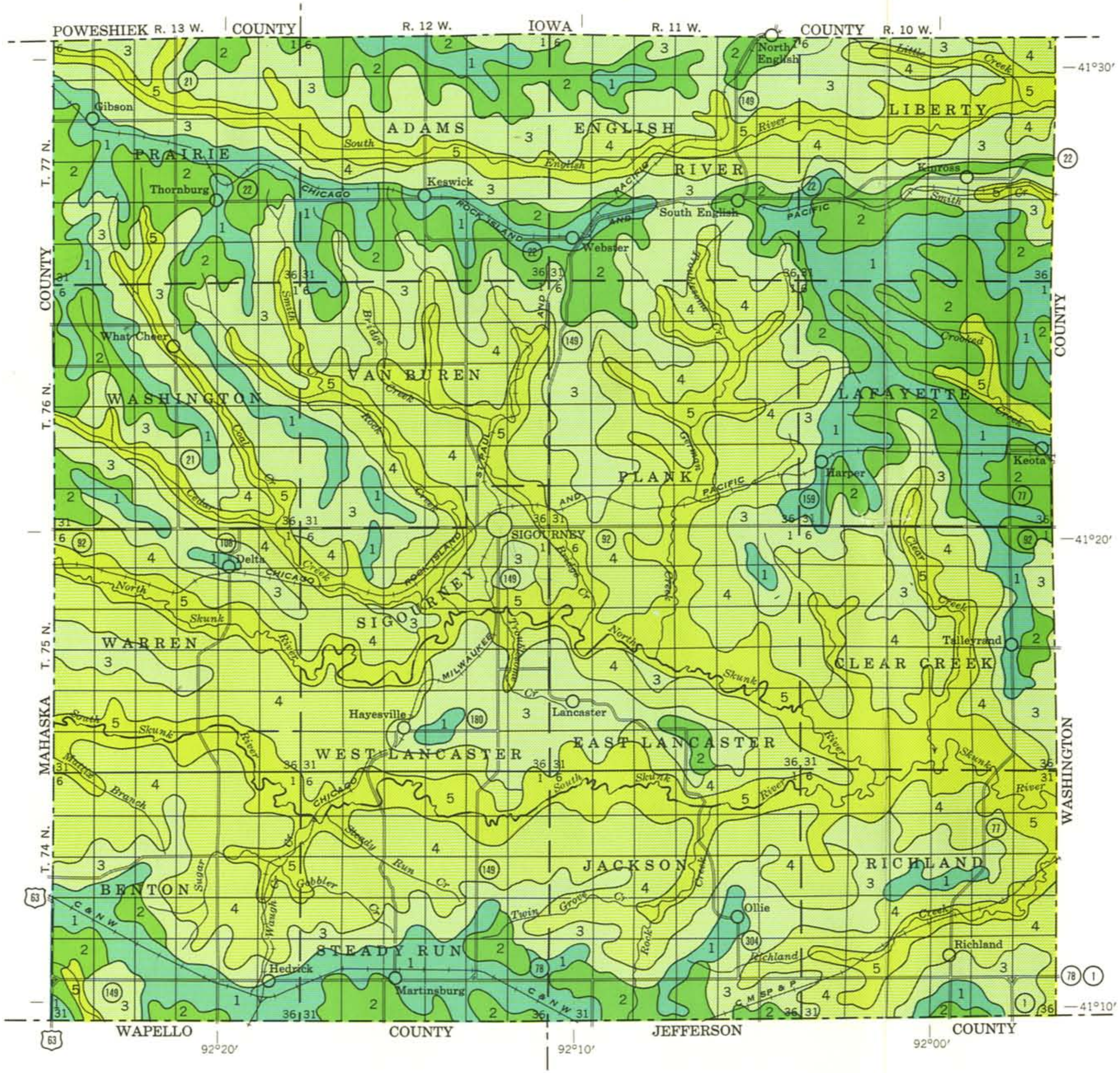
Acreage and extent, table 2, page 9.
Predicted yields, table 3, page 68.
Use of the soils for engineering, tables 4, 5, and 6, page 74 through page 97.

Map symbol	Mapping unit	Described on page	Capability unit Symbol	Capability unit Page	Woodland suitability group Number	Woodland suitability group Page
AaC2	Adair clay loam, 5 to 9 percent slopes, moderately eroded	11	IIIe-2	64	7	72
AaD2	Adair clay loam, 9 to 14 percent slopes, moderately eroded	11	IVe-2	66	7	72
AdD3	Adair soils, 9 to 14 percent slopes, severely eroded	12	VIe-1	66	7	72
AhE2	Adair-Shelby complex, 14 to 18 percent slopes, moderately eroded	12	VIe-1	66	7	72
AhE3	Adair-Shelby complex, 14 to 18 percent slopes, severely eroded	12	VIIe-1	67	7	72
Al	Alluvial land, channeled	12	Vw-1	66	9	72
Am	Alluvial land-Nodaway complex	12	Vw-1	66	9	72
An	Amana silt loam	13	I-2	62	9	72
Ao	Amana silt loam, channeled	13	Vw-1	66	9	72
BoE	Boone fine sandy loam, 10 to 20 percent slopes	14	VIIs-1	67	6	72
CaE	Chelsea loamy fine sand, 9 to 18 percent slopes	15	VIIs-1	67	5	71
Cb	Chequest silt loam, overwash	16	IIw-1	62	10	72
Cc	Chequest silty clay loam	16	IIw-1	62	10	72
CdC2	Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded	17	IIIe-2	64	8	72
CdD2	Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded	17	IVe-2	66	8	72
ClB	Clinton silt loam, 2 to 5 percent slopes	18	IIe-1	62	1	70
ClC	Clinton silt loam, 5 to 9 percent slopes	18	IIIe-1	64	1	70
ClC2	Clinton silt loam, 5 to 9 percent slopes, moderately eroded	19	IIIe-1	64	1	70
ClD	Clinton silt loam, 9 to 14 percent slopes	19	IIIe-1	64	1	70
ClD2	Clinton silt loam, 9 to 14 percent slopes, moderately eroded	19	IIIe-1	64	1	70
ClE2	Clinton silt loam, 14 to 18 percent slopes, moderately eroded	19	IVe-1	65	1	70
CmC2	Clinton silt loam, benches, 5 to 9 percent slopes, moderately eroded	19	IIIe-1	64	1	70
CnC3	Clinton soils, 5 to 9 percent slopes, severely eroded	20	IIIe-1	64	1	70
CnD3	Clinton soils, 9 to 14 percent slopes, severely eroded	20	IVe-1	65	1	70
CnE3	Clinton soils, 14 to 18 percent slopes, severely eroded	20	VIe-1	66	1	70
Co	Colo silt loam, overwash	21	IIw-1	62	10	72
Cs	Colo silty clay loam	21	IIw-1	62	10	72
CsB	Colo silty clay loam, 2 to 5 percent slopes	21	IIw-3	63	10	72
CtB	Colo-Ely silty clay loams, 2 to 5 percent slopes	21	IIw-3	63	10	72
DhB	Dickinson-Sparta complex, 2 to 5 percent slopes	22	IIIs-1	65	5	71
DlC2	Dickinson-Sparta-Ladoga complex, 5 to 9 percent slopes, moderately eroded	22	IIIs-1	65	5	71
DlD2	Dickinson-Sparta-Ladoga complex, 9 to 14 percent slopes, moderately eroded	23	IVe-1	65	5	71
DuE3	Dunbarton silt loam, 10 to 20 percent slopes, severely eroded	24	VIIs-1	67	6	72
ElB	Ely silty clay loam, 3 to 7 percent slopes	24	IIe-2	62	4	71
GaD2	Gara loam, 9 to 14 percent slopes, moderately eroded	25	IVe-3	66	2	70
GaE	Gara loam, 14 to 18 percent slopes	26	VIe-1	66	2	70
GaE2	Gara loam, 14 to 18 percent slopes, moderately eroded	26	VIe-1	66	2	70
GaF2	Gara loam, 18 to 25 percent slopes, moderately eroded	26	VIIe-1	67	3	71

Map symbol	Mapping unit	Described on page	Capability unit		Woodland suitability group	
			Symbol	Page	Number	Page
GrE3	Gara soils, 14 to 18 percent slopes, severely eroded	26	VIIe-1	67	2	70
GsA	Givin silt loam, 1 to 3 percent slopes	27	I-1	61	4	71
GtA	Givin silt loam, benches, 1 to 3 percent slopes	27	I-1	61	4	71
GuE2	Gosport silt loam, 14 to 25 percent slopes, moderately eroded	28	VIIe-1	67	8	72
Hu	Humeston silt loam	29	IIIw-2	65	10	72
JcC	Judson silty clay loam, 3 to 7 percent slopes	30	IIe-2	62	1	70
KeA	Keomah silt loam, 1 to 3 percent slopes	31	I-1	61	4	71
KsD	Keswick loam, 9 to 14 percent slopes	32	IVe-2	66	7	72
KsD2	Keswick loam, 9 to 14 percent slopes, moderately eroded	32	IVe-2	66	7	72
KwD3	Keswick soils, 9 to 14 percent slopes, severely eroded	32	VIe-1	66	7	72
KxE3	Keswick-Lindley complex, 14 to 18 percent slopes, severely eroded	32	VIIe-1	67	7	72
KyE2	Keswick-Lindley loams, 14 to 18 percent slopes, moderately eroded	33	VIe-1	66	7	72
KzA	Koszta silt loam, 1 to 3 percent slopes	33	I-1	61	4	71
LaB	Ladoga silt loam, 2 to 5 percent slopes	34	IIe-1	62	1	70
LaC	Ladoga silt loam, 5 to 9 percent slopes	34	IIIe-1	64	1	70
LaC2	Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	35	IIIe-1	64	1	70
LaD	Ladoga silt loam, 9 to 14 percent slopes	35	IIIe-1	64	1	70
LaD2	Ladoga silt loam, 9 to 14 percent slopes, moderately eroded	35	IIIe-1	64	1	70
LbB	Ladoga silt loam, benches, 2 to 5 percent slopes	35	IIe-1	62	1	70
LdC3	Ladoga soils, 5 to 9 percent slopes, severely eroded	36	IIIe-1	64	1	70
LdD3	Ladoga soils, 9 to 14 percent slopes, severely eroded	36	IVe-1	65	1	70
LmC2	Lamoni silty clay loam, 5 to 9 percent slopes, moderately eroded	37	IIIe-2	64	8	72
LmD2	Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded	37	IVe-2	66	8	72
LnD2	Lamoni soils, 9 to 14 percent slopes, severely eroded	37	VIe-1	66	8	72
LoE2	Lamoni-Shelby complex, 14 to 18 percent slopes, moderately eroded	38	VIe-1	66	8	72
LpC2	Lamont-Clinton-Chelsea complex, 5 to 9 percent slopes, moderately eroded	38	IIIs-1	65	5	71
LpD2	Lamont-Clinton-Chelsea complex, 9 to 14 percent slopes, moderately eroded	39	IVe-1	65	5	71
LpE2	Lamont-Clinton-Chelsea complex, 14 to 18 percent slopes, moderately eroded	39	VIe-1	66	5	71
LpF2	Lamont-Clinton-Chelsea complex, 18 to 30 percent slopes, moderately eroded	39	VIIe-1	67	5	71
LrD2	Lindley loam, 9 to 14 percent slopes, moderately eroded	40	IVe-3	66	2	70
LrE	Lindley loam, 14 to 18 percent slopes	40	VIe-1	66	2	70
LrE2	Lindley loam, 14 to 18 percent slopes, moderately eroded	40	VIe-1	66	2	70
LrF	Lindley loam, 18 to 25 percent slopes	41	VIIe-1	67	3	71
LrF2	Lindley loam, 18 to 25 percent slopes, moderately eroded	41	VIIe-1	67	3	71
LrG	Lindley loam, 25 to 40 percent slopes	41	VIIe-1	67	3	71
LsE3	Lindley soils, 14 to 18 percent slopes, severely eroded	41	VIIe-1	67	2	70
MaA	Mahaska silty clay loam, 1 to 3 percent slopes	42	I-1	61	4	71
MhA	Mahaska silty clay loam, benches, 1 to 3 percent slopes	42	I-1	61	4	71
MrB	Martinsburg silt loam, 2 to 5 percent slopes	43	IIe-2	62	1	70
MrC	Martinsburg silt loam, 5 to 9 percent slopes	44	IIIe-1	64	1	70
NgB	Nira-Givin complex, 1 to 3 percent slopes	44	IIe-1	62	4	71

Map symbol	Mapping unit	Described on page	Capability unit Symbol	Capability unit Page	Woodland suitability group Number	Woodland suitability group Page
NmB	Nira-Mahaska silty clay loams, 1 to 3 percent slopes	45	IIe-1	62	4	71
No	Nodaway silt loam	45	I-2	62	9	72
Ns	Nodaway silt loam, channeled	46	Vw-1	66	9	72
NwB	Nodaway-Martinsburg silt loams, 2 to 5 percent slopes	46	IIw-3	63	9	72
OlC	Olmitz loam, 3 to 7 percent slopes	47	IIe-2	62	2	70
OtB	Otley silty clay loam, 2 to 5 percent slopes	48	IIe-1	62	1	70
OtC	Otley silty clay loam, 5 to 9 percent slopes	48	IIIe-1	64	1	70
OtC2	Otley silty clay loam, 5 to 9 percent slopes, moderately eroded	48	IIIe-1	64	1	70
OtD2	Otley silty clay loam, 9 to 14 percent slopes, moderately eroded	48	IIIe-1	64	1	70
Ra	Radford silt loam	49	I-2	62	9	72
ReB	Radford-Ely complex, 2 to 5 percent slopes	49	IIw-3	63	9	72
Ru	Rubio silt loam	50	IIIw-2	65	10	72
ShE2	Shelby loam, 14 to 18 percent slopes, moderately eroded	51	IVe-3	66	2	70
SoF	Sogn soils, 15 to 30 percent slopes	52	VIIs-1	67	6	72
Sp	Sperry silt loam	53	IIIw-2	65	10	72
Ta	Taintor silty clay loam	54	IIw-2	62	10	72
Tb	Taintor silty clay loam, benches	55	IIw-2	62	10	72
Tu	Tuskeego silt loam	55	IIIw-2	65	10	72
Ve	Vesser silt loam	56	IIw-1	62	10	72
VeB	Vesser silt loam, 2 to 5 percent slopes	57	IIw-3	63	10	72
Wa	Wabash silt loam, overwash	58	IIIw-1	65	10	72
Wc	Wabash silty clay loam	58	IIIw-1	65	10	72
WkA	Watkins silt loam, 0 to 2 percent slopes	59	I-1	61	1	70
WkB	Watkins silt loam, 2 to 5 percent slopes	59	IIe-1	62	1	70
Zk	Zook silt loam, overwash	60	IIIw-1	65	10	72
Zo	Zook silty clay loam	60	IIIw-1	65	10	72

Accessibility Statement



SOIL ASSOCIATIONS

1 — Mahaska-Taintor association: Nearly level, somewhat poorly drained and poorly drained soils that have a subsoil of silty clay loam and silty clay; formed in loess on uplands

2 — Otley-Clarinda-Adair association: Gently sloping to steep, moderately well drained to poorly drained soils that have a subsoil of silty clay loam to clay; formed in loess and glacial till, dominantly on uplands

3 — Ladoga-Givin-Gara association: Nearly level to steep, moderately well drained and somewhat poorly drained soils that have a subsoil of silty clay loam and clay loam; formed in loess and glacial till, dominantly on uplands

4 — Clinton-Keswick-Lindley association: Sloping to very steep, moderately well drained soils that have a dominantly clay to sandy clay loam subsoil; formed in loess and glacial till on uplands

5 — Amana-Alluvial land-Nodaway association: Nearly level and undulating, well-drained to very poorly drained soils formed in alluvium on bottom lands

February 1970

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
IOWA AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP

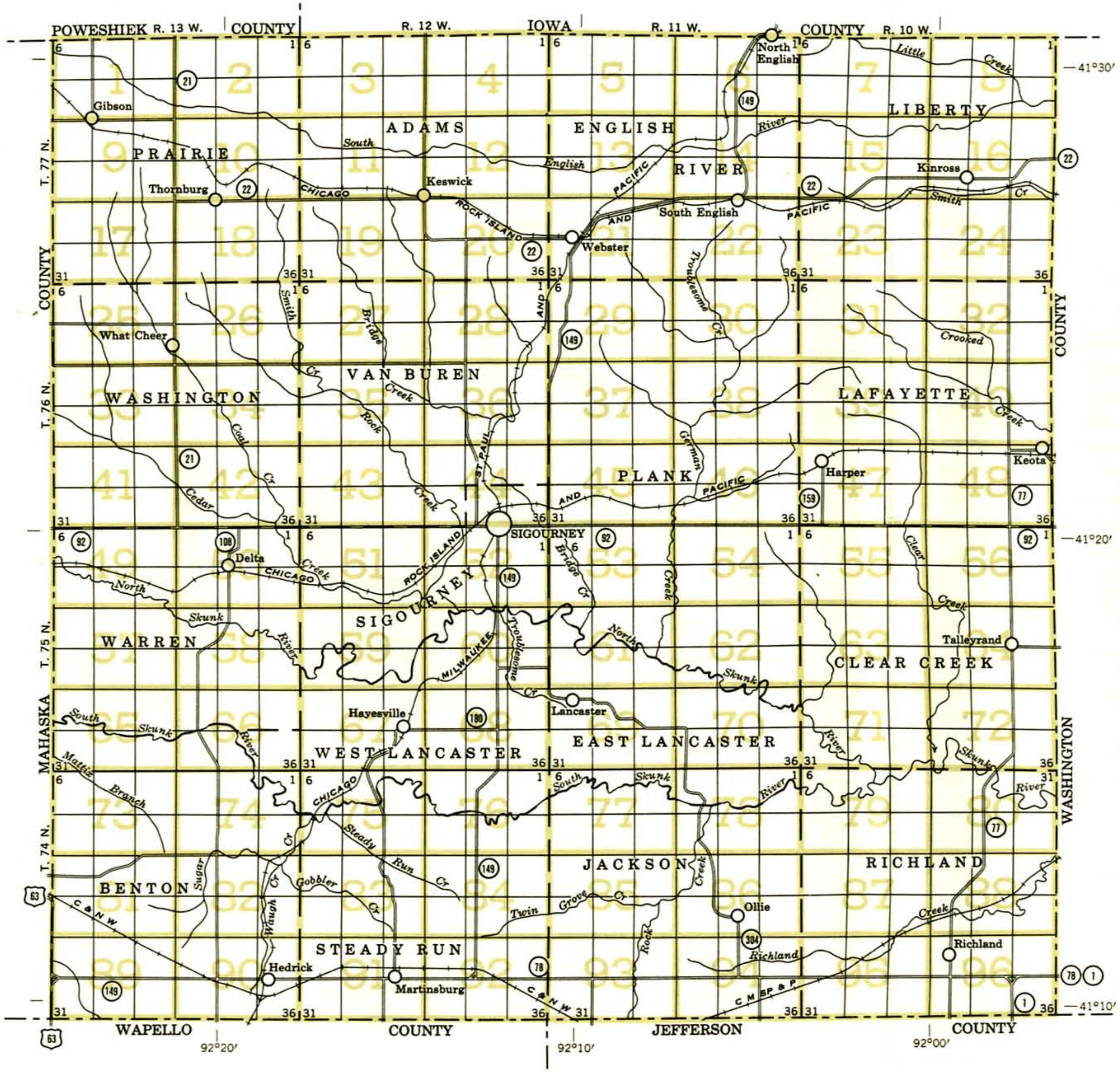
KEOKUK COUNTY, IOWA

Scale 1:190080

1 0 1 2 3 4 Miles

NOTE—

This map is intended for general planning. Each delineation may contain soils having ratings different from those shown on the map. Use detailed soil maps for operational planning.



INDEX TO MAP SHEETS

KEOKUK COUNTY, IOWA

Scale 1:190080

1 0 1 2 3 4 Miles

SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, D, E, F, or G, shows the slope. Most symbols without a slope letter are those of nearly level soils or land types. Soils that are named as moderately eroded or severely eroded have a final number, 2 or 3, in their symbol.

SYMBOL	NAME
AaC2	Adair clay loam, 5 to 9 percent slopes, moderately eroded
AaD2	Adair clay loam, 9 to 14 percent slopes, moderately eroded
AdD3	Adair soils, 9 to 14 percent slopes, severely eroded
AhE2	Adair-Shelby complex, 14 to 18 percent slopes, moderately eroded
AhE3	Adair-Shelby complex, 14 to 18 percent slopes, severely eroded
Al	Alluvial land, channeled
Am	Alluvial land-Nodaway complex
An	Amana silt loam
Ao	Amana silt loam, channeled
BoE	Boone fine sandy loam, 10 to 20 percent slopes
CaE	Chelsea loamy fine sand, 9 to 18 percent slopes
Cb	Chequest silt loam, overwash
Cc	Chequest silty clay loam
CdC2	Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded
CdD2	Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded
ClB	Clinton silt loam, 2 to 5 percent slopes
ClC	Clinton silt loam, 5 to 9 percent slopes
ClC2	Clinton silt loam, 5 to 9 percent slopes, moderately eroded
ClD	Clinton silt loam, 9 to 14 percent slopes
ClD2	Clinton silt loam, 9 to 14 percent slopes, moderately eroded
ClE2	Clinton silt loam, 14 to 18 percent slopes, moderately eroded
CmC2	Clinton silt loam, benches, 5 to 9 percent slopes, moderately eroded
CnC3	Clinton soils, 5 to 9 percent slopes, severely eroded
CnD3	Clinton soils, 9 to 14 percent slopes, severely eroded
CnE3	Clinton soils, 14 to 18 percent slopes, severely eroded
Co	Colo silt loam, overwash
Cs	Colo silty clay loam
CsB	Colo silty clay loam, 2 to 5 percent slopes
CtB	Colo-Ely silty clay loams, 2 to 5 percent slopes
DhB	Dickinson-Sparta complex, 2 to 5 percent slopes
DlC2	Dickinson-Sparta-Ladoga complex, 5 to 9 percent slopes, moderately eroded
DlD2	Dickinson-Sparta-Ladoga complex, 9 to 14 percent slopes, moderately eroded
DuE3	Dunbarton silt loam, 10 to 20 percent slopes, severely eroded
ElB	Ely silty clay loam, 3 to 7 percent slopes
GaD2	Gara loam, 9 to 14 percent slopes, moderately eroded
GaE	Gara loam, 14 to 18 percent slopes
GaE2	Gara loam, 14 to 18 percent slopes, moderately eroded
GaF2	Gara loam, 18 to 25 percent slopes, moderately eroded
GrE3	Gara soils, 14 to 18 percent slopes, severely eroded
GsA	Givin silt loam, 1 to 3 percent slopes
GtA	Givin silt loam, benches, 1 to 3 percent slopes
GuE2	Gosport silt loam, 14 to 25 percent slopes, moderately eroded
Hu	Humeston silt loam
JcC	Judson silty clay loam, 3 to 7 percent slopes
KeA	Keomah silt loam, 1 to 3 percent slopes
KsD	Keswick loam, 9 to 14 percent slopes
KsD2	Keswick loam, 9 to 14 percent slopes, moderately eroded
KwD3	Keswick soils, 9 to 14 percent slopes, severely eroded
KxE3	Keswick-Lindley complex, 14 to 18 percent slopes, severely eroded
KyE2	Keswick-Lindley loams, 14 to 18 percent slopes, moderately eroded
KzA	Koszta silt loam, 1 to 3 percent slopes
LaB	Ladoga silt loam, 2 to 5 percent slopes
LaC	Ladoga silt loam, 5 to 9 percent slopes
LaC2	Ladoga silt loam, 5 to 9 percent slopes, moderately eroded
LaD	Ladoga silt loam, 9 to 14 percent slopes
LaD2	Ladoga silt loam, 9 to 14 percent slopes, moderately eroded
LbB	Ladoga silt loam, benches, 2 to 5 percent slopes
LdC3	Ladoga soils, 5 to 9 percent slopes, severely eroded
LdD3	Ladoga soils, 9 to 14 percent slopes, severely eroded
LmC2	Lamoni silty clay loam, 5 to 9 percent slopes, moderately eroded
LmD2	Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded
LnD3	Lamoni soils, 9 to 14 percent slopes, severely eroded
LoE2	Lamoni-Shelby complex, 14 to 18 percent slopes, moderately eroded
LpC2	Lamont-Clinton-Chelsea complex, 5 to 9 percent slopes, moderately eroded
LpD2	Lamont-Clinton-Chelsea complex, 9 to 14 percent slopes, moderately eroded
LpE2	Lamont-Clinton-Chelsea complex, 14 to 18 percent slopes, moderately eroded
LpF2	Lamont-Clinton-Chelsea complex, 18 to 30 percent slopes, moderately eroded
LrD2	Lindley loam, 9 to 14 percent slopes, moderately eroded
LrE	Lindley loam, 14 to 18 percent slopes
LrE2	Lindley loam, 14 to 18 percent slopes, moderately eroded
LrF	Lindley loam, 18 to 25 percent slopes
LrF2	Lindley loam, 18 to 25 percent slopes, moderately eroded
LrG	Lindley loam, 25 to 40 percent slopes
LsE3	Lindley soils, 14 to 18 percent slopes, severely eroded
MaA	Mahaska silty clay loam, 1 to 3 percent slopes
MhA	Mahaska silty clay loam, benches, 1 to 3 percent slopes
MrB	Martinsburg silt loam, 2 to 5 percent slopes
MrC	Martinsburg silt loam, 5 to 9 percent slopes
NgB	Nira-Givin complex, 1 to 3 percent slopes
NmB	Nira-Mahaska silty clay loams, 1 to 3 percent slopes
No	Nodaway silt loam
Ns	Nodaway silt loam, channeled
NwB	Nodaway-Martinsburg silt loams, 2 to 5 percent slopes
OlC	Olmitz loam, 3 to 7 percent slopes
OtB	Otley silty clay loam, 2 to 5 percent slopes
OtC	Otley silty clay loam, 5 to 9 percent slopes
OtC2	Otley silty clay loam, 5 to 9 percent slopes, moderately eroded
OtD2	Otley silty clay loam, 9 to 14 percent slopes, moderately eroded
Ra	Radford silt loam
ReB	Radford-Ely complex, 2 to 5 percent slopes
Ru	Rubio silt loam
ShE2	Shelby loam, 14 to 18 percent slopes, moderately eroded
SoF	Sogn soils, 15 to 30 percent slopes
Sp	Sperry silt loam
Ta	Taintor silty clay loam
Tb	Taintor silty clay loam, benches
Tu	Tuskeego silt loam
Ve	Vesser silt loam
VeB	Vesser silt loam, 2 to 5 percent slopes
Wa	Wabash silt loam, overwash
Wc	Wabash silty clay loam
WkA	Watkins silt loam, 0 to 2 percent slopes
WkB	Watkins silt loam, 2 to 5 percent slopes
Zk	Zook silt loam, overwash
Zo	Zook silty clay loam

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Dual
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State or county

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail
- Railroad
- Ferry (FY)
- Ford (FORD)
- Grade
- R. R. over
- R. R. under

Tunnel

Buildings
- School
- Church

Mine and quarry or gravel

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Well, oil or gas

Forest fire or lookout station

Windmill

BOUNDARIES

- National or state
- County
- Minor civil division
- Reservation
- Land grant
- Small park, cemetery, airport
- Land survey division corners

DRAINAGE

Streams, double-line
- Perennial
- Intermittent

Streams, single-line
- Perennial
- Intermittent
  - Crossable with tillage implements
  - Not crossable with tillage implements
- Stable grade

Canals and ditches (CANAL)

Lakes and ponds
- Perennial (water, w)
- Intermittent

Spring

Marsh or swamp

Wet spot

Alluvial fan

Drainage end

RELIEF

Escarpments
- Bedrock
- Other

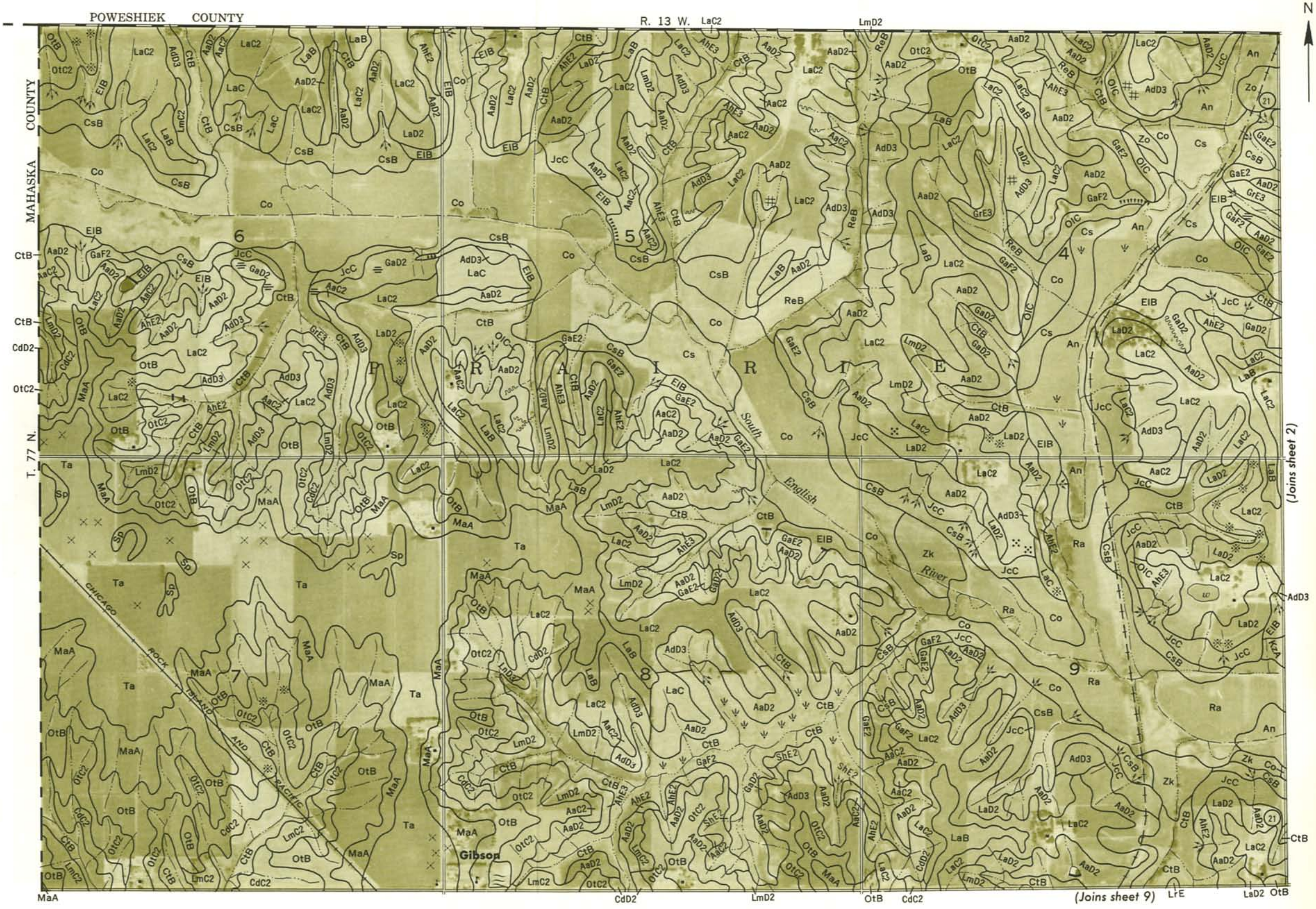
Prominent peak

Depressions (Large, Small)
- Crossable with tillage implements
- Not crossable with tillage implements
- Contains water most of the time

SOIL SURVEY DATA

- Soil boundary and symbol (Dx)
- Gravel
- Stoniness: Stony; Very stony
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion, sand
- Gully
- Borrow pit (B.P.)
- Gray spot with clay subsoil
- Glacial till, undifferentiated
- Shale outcrops

Soil map constructed 1968 by Cartographic Division, Soil Conservation Service, USDA, from 1963 aerial photographs. Controlled mosaic based on Iowa plane coordinate system, south zone, Lambert conformal conic projection, 1927 North American datum.

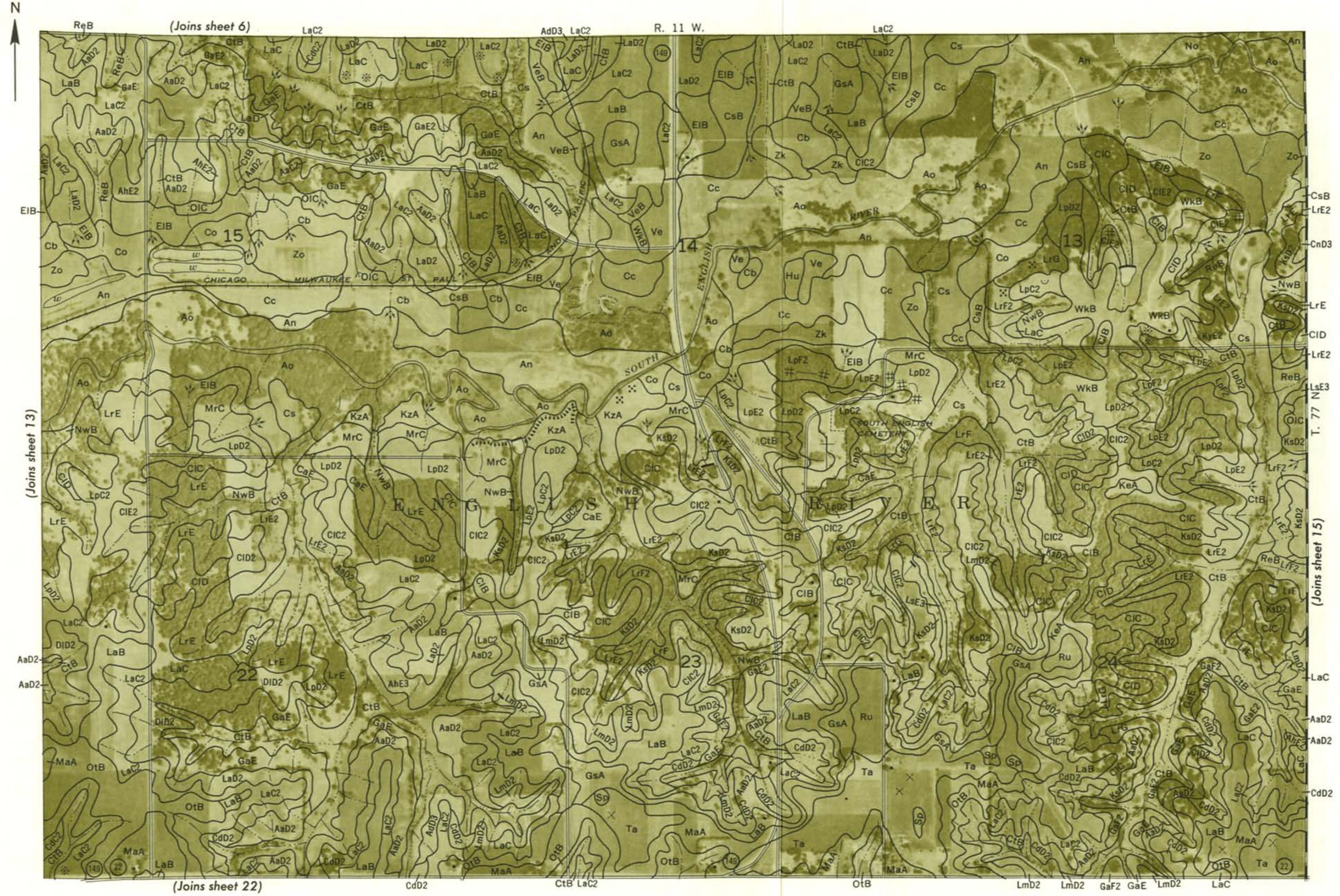

POWESHIEK COUNTY
R. 13 W.
N
MAHASKA COUNTY
T. 77 N.
P R A I R I E
South English River
CHICAGO ROCK ISLAND AND PACIFIC
Gibson
(Joins sheet 2)
(Joins sheet 9)


N
(Joins sheet 2)
R. 13 W.
T. 77 N.
(Joins sheet 9)
(Joins sheet 11)
(Joins sheet 18)
South English River
White Oak Church
P R A I R I E
Sixteen Cemetery
Chicago Rock Island and Pacific
Thornburg
15
14
13
22
23
24

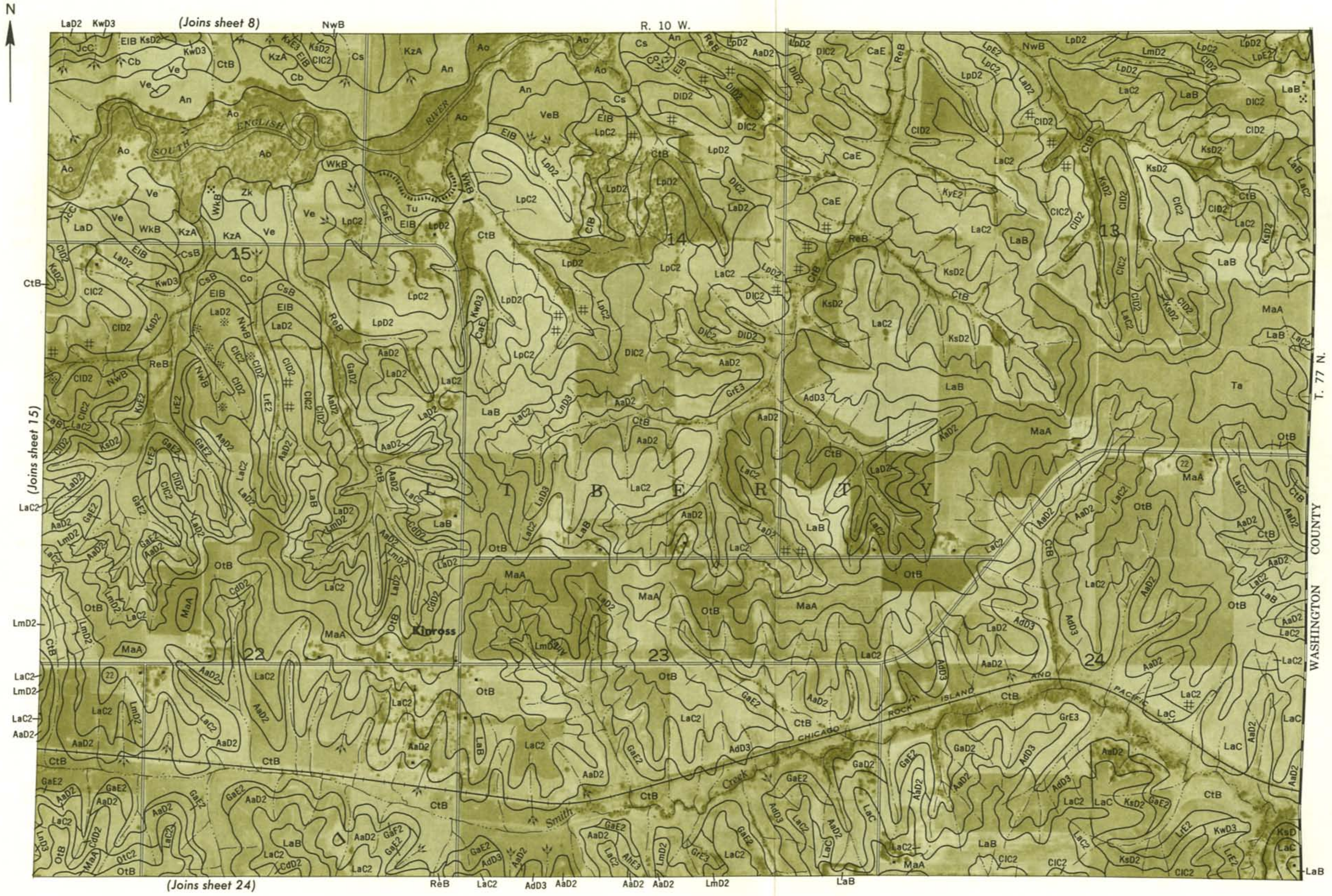

N
R. 12 W.
(Joins sheet 3)
(Joins sheet 12)
(Joins sheet 19)
(Joins sheet 10)
T. 77 N.
A D A M S
South English River
CHICAGO ROCK ISLAND AND PACIFIC
QUARRY & SPOIL
Keswick
18
17
16
19
20
21


N
(Joins sheet 4)
R. 12 W.
T. 77 N.
(Joins sheet 11)
(Joins sheet 13)
(Joins sheet 20)
A D A M S
South English River
Keswick
SORDEN CEMETERY
C R I & P
15
14
13
22
23
24
22


(Joins sheet 5)
(Joins sheet 14)
(Joins sheet 21)
(Joins sheet 12)
R. 11 W.
T. 77 N.
N
ENGLISH RIVER
South English River
CHICAGO MILWAUKEE ST. PAUL AND PACIFIC
16
17
18
19
20
21


N
(Joins sheet 6)
R. 11 W.
(Joins sheet 13)
(Joins sheet 15)
(Joins sheet 22)
T. 77 N.
ENGLISH RIVER
SOUTH ENGLISH RIVER
CHICAGO MILWAUKEE ST PAUL PACIFIC
SOUTH ENGLISH CEMETERY
15
14
13
22
23
24


N
R. 10 W.
(Joins sheet 7)
T. 77 N.
(Joins sheet 14)
(Joins sheet 16)
(Joins sheet 23)
SOUTH ENGLISH RIVER
L I B E R T Y
Brethren Church
Smith Creek
18
17
16
19
20
21


N
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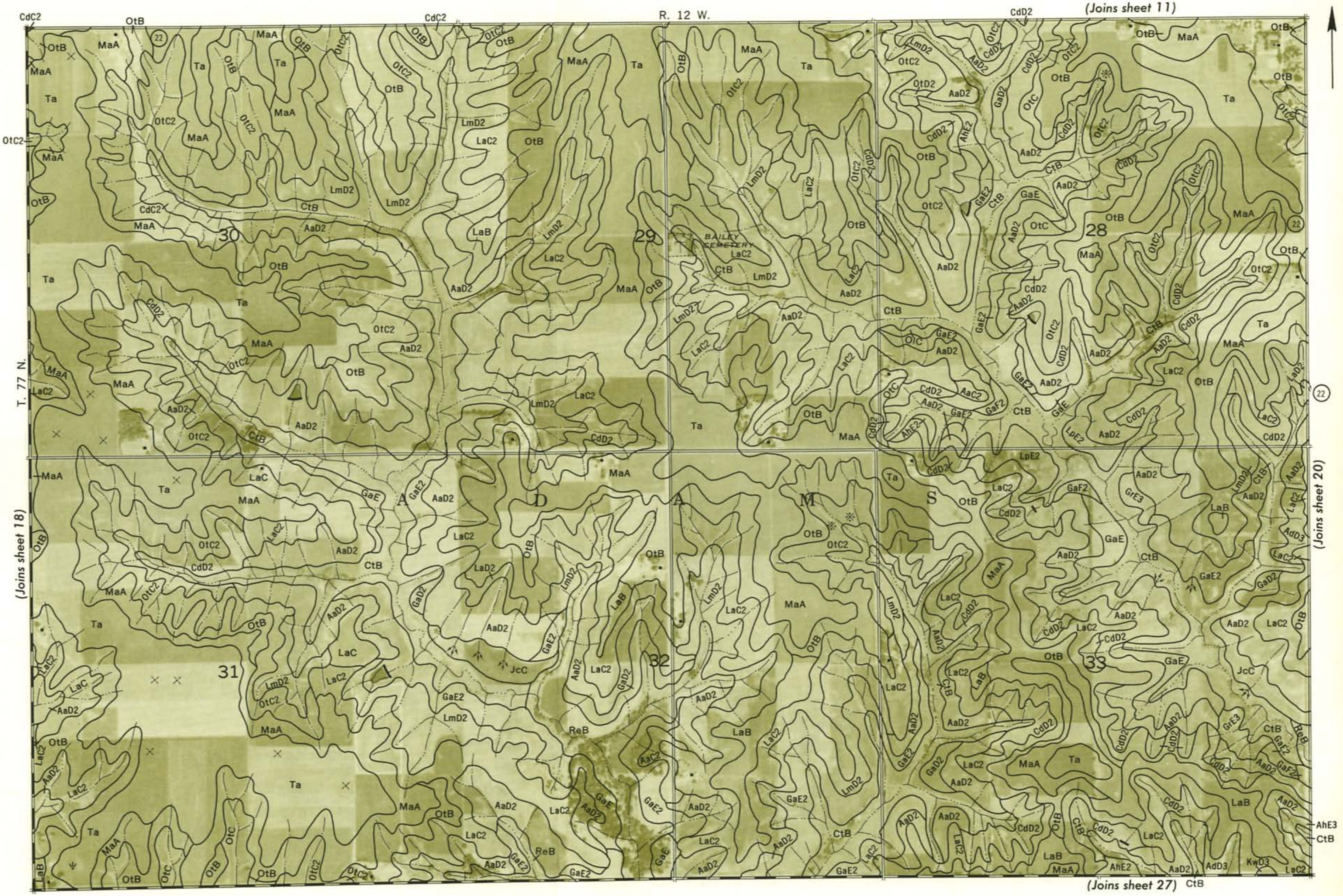
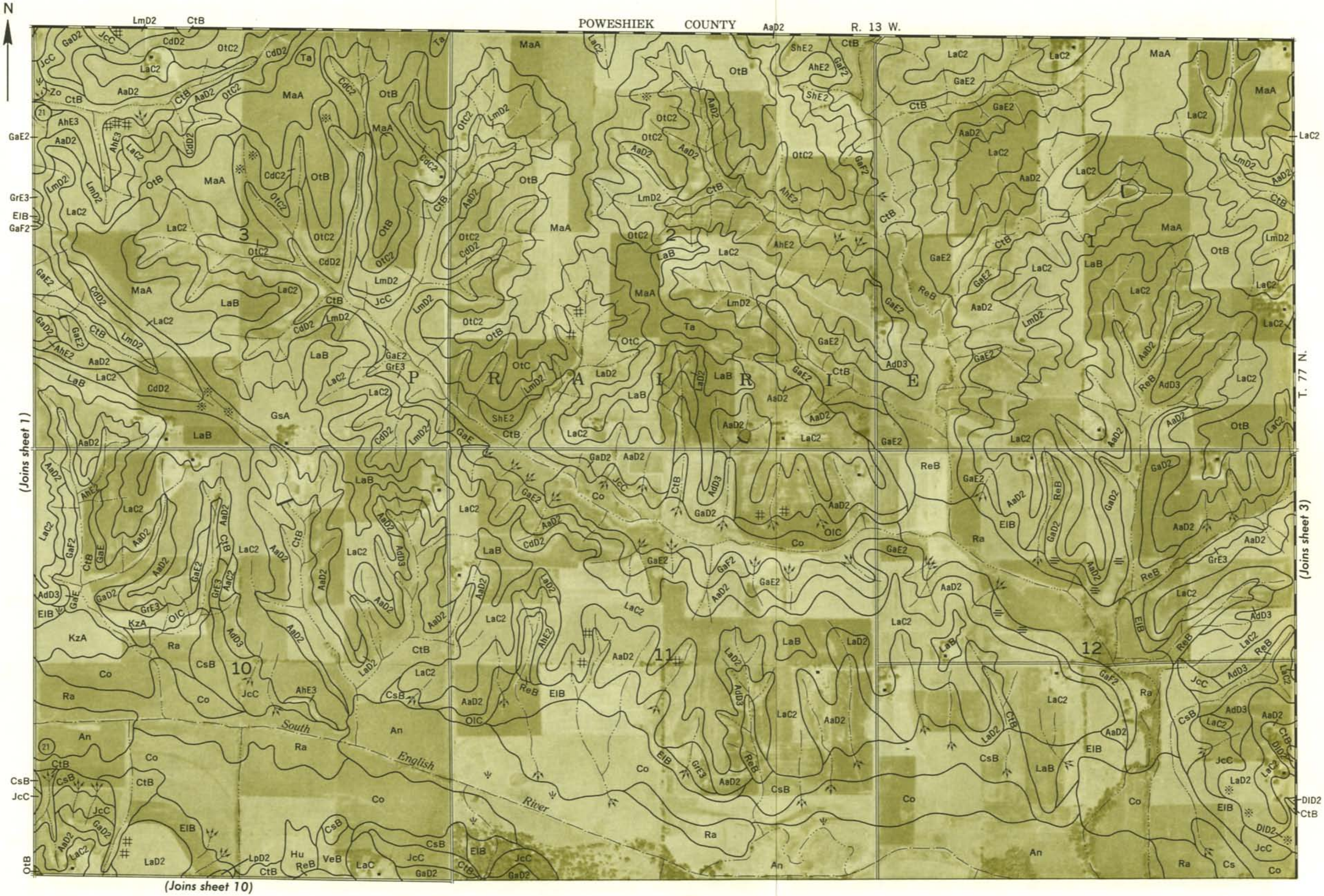
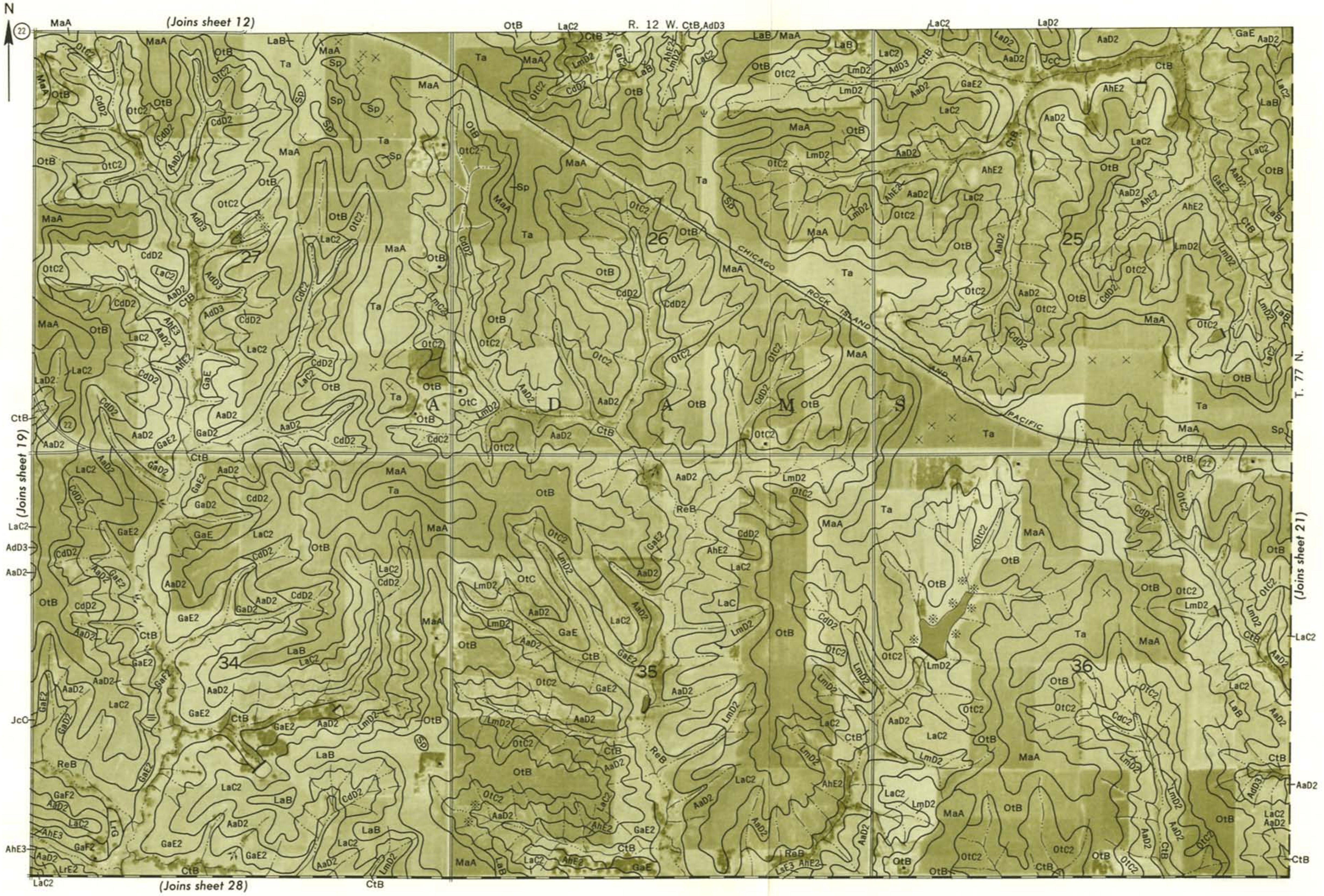
R. 10 W.
(Joins sheet 15)
T. 77 N.
WASHINGTON COUNTY
(Joins sheet 24)
SOUTH ENGLISH RIVER
LIBERTY
Kinross
CHICAGO ROCK ISLAND AND PACIFIC
Smith Creek
15
14
13
22
23
24
22

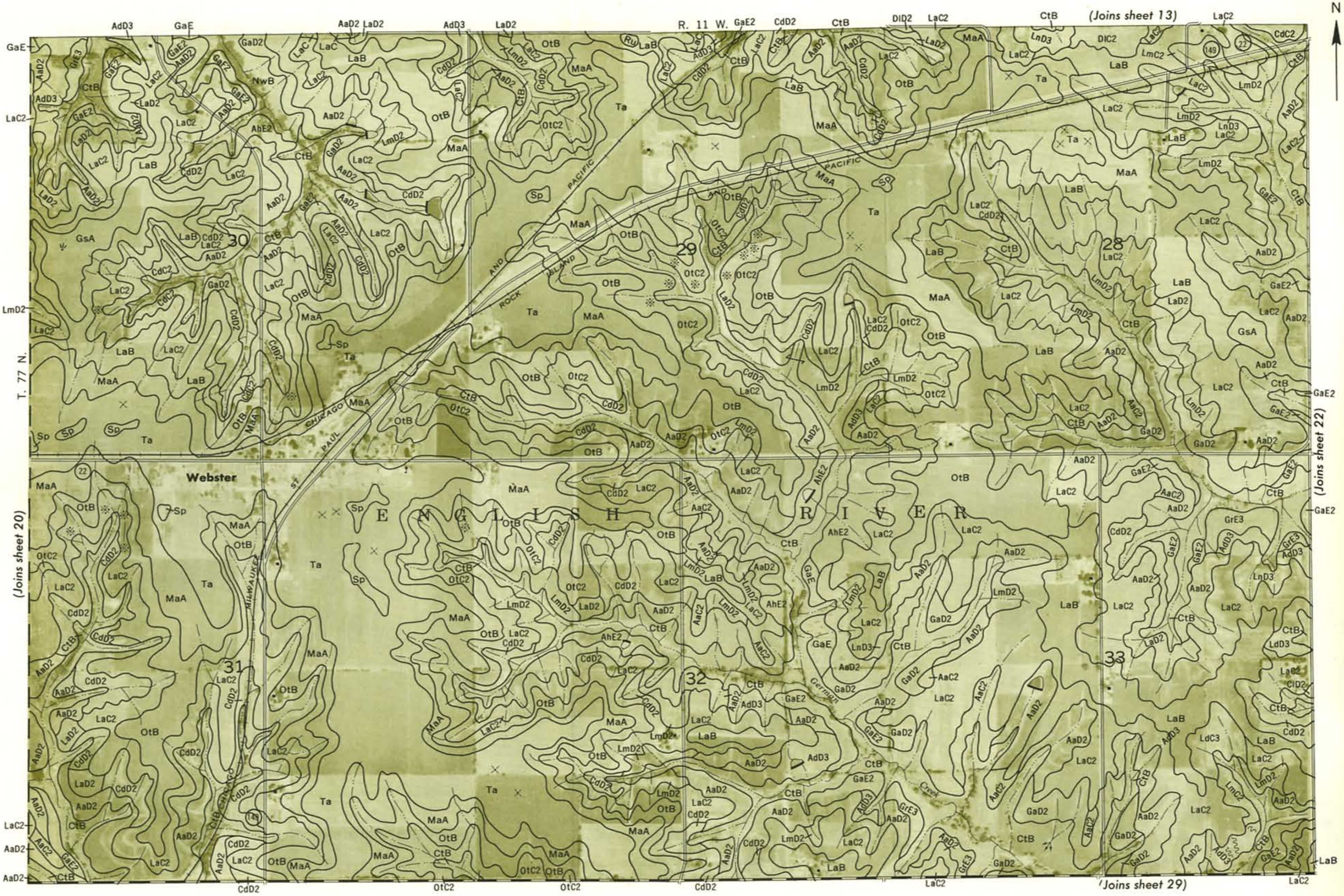

N
(Joins sheet 9)
R. 13 W.
T. 77 N.
MAHASKA COUNTY
(Joins sheet 18)
(Joins sheet 25)
P R A I R I E
Coal Creek
Coal Creek
29
28
30
31
32
33


N
(Joins sheet 10)
R. 13 W.
T. 77 N.
(Joins sheet 17)
(Joins sheet 19)
(Joins sheet 26)
P R A I R I E
27
26
25
34
35
36
Smith Creek

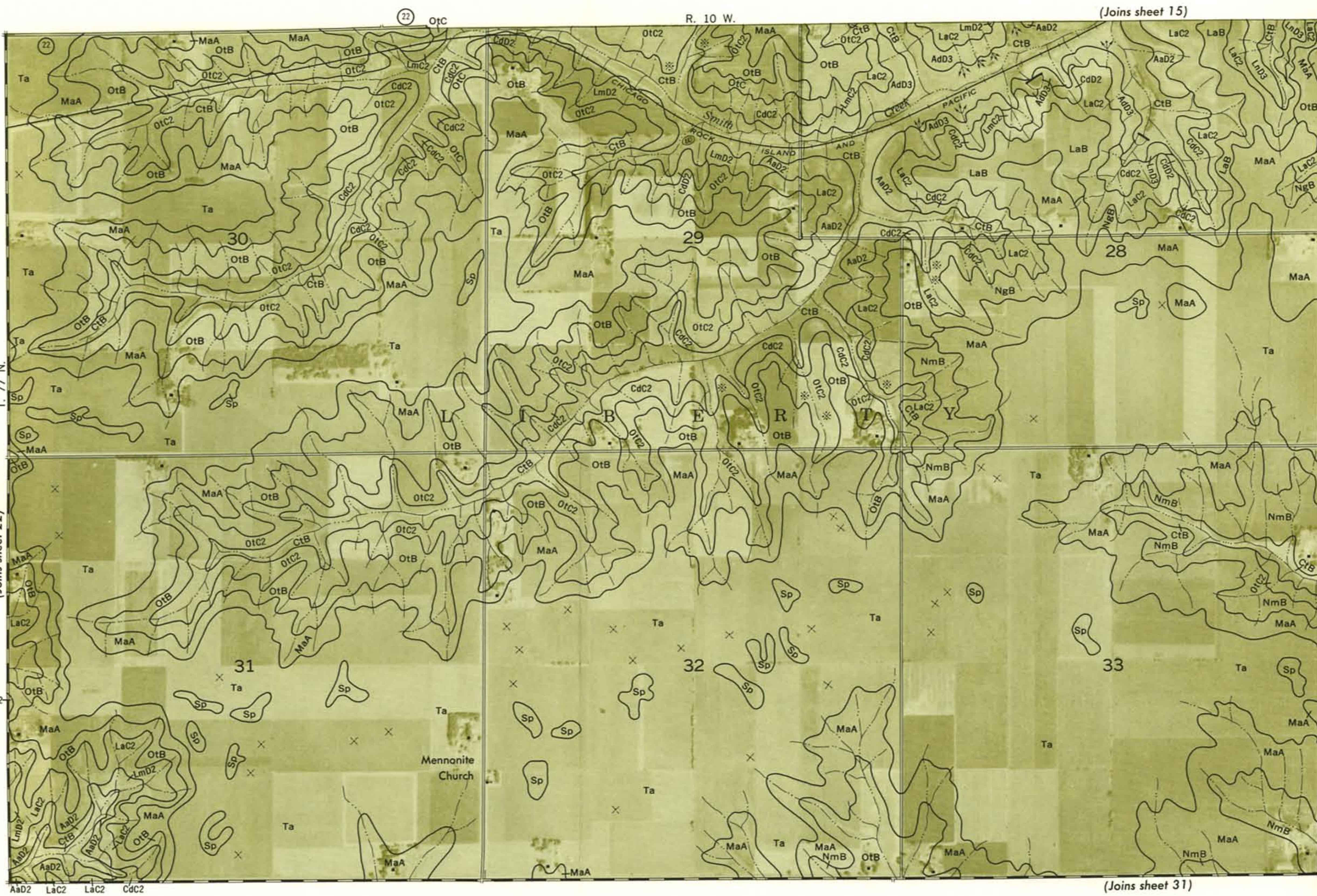

N
R. 12 W.
(Joins sheet 11)
(Joins sheet 18)
(Joins sheet 20)
(Joins sheet 27)
T. 77 N.
ADAMS
BAILEY CEMETERY
30
29
28
31
32
33
22

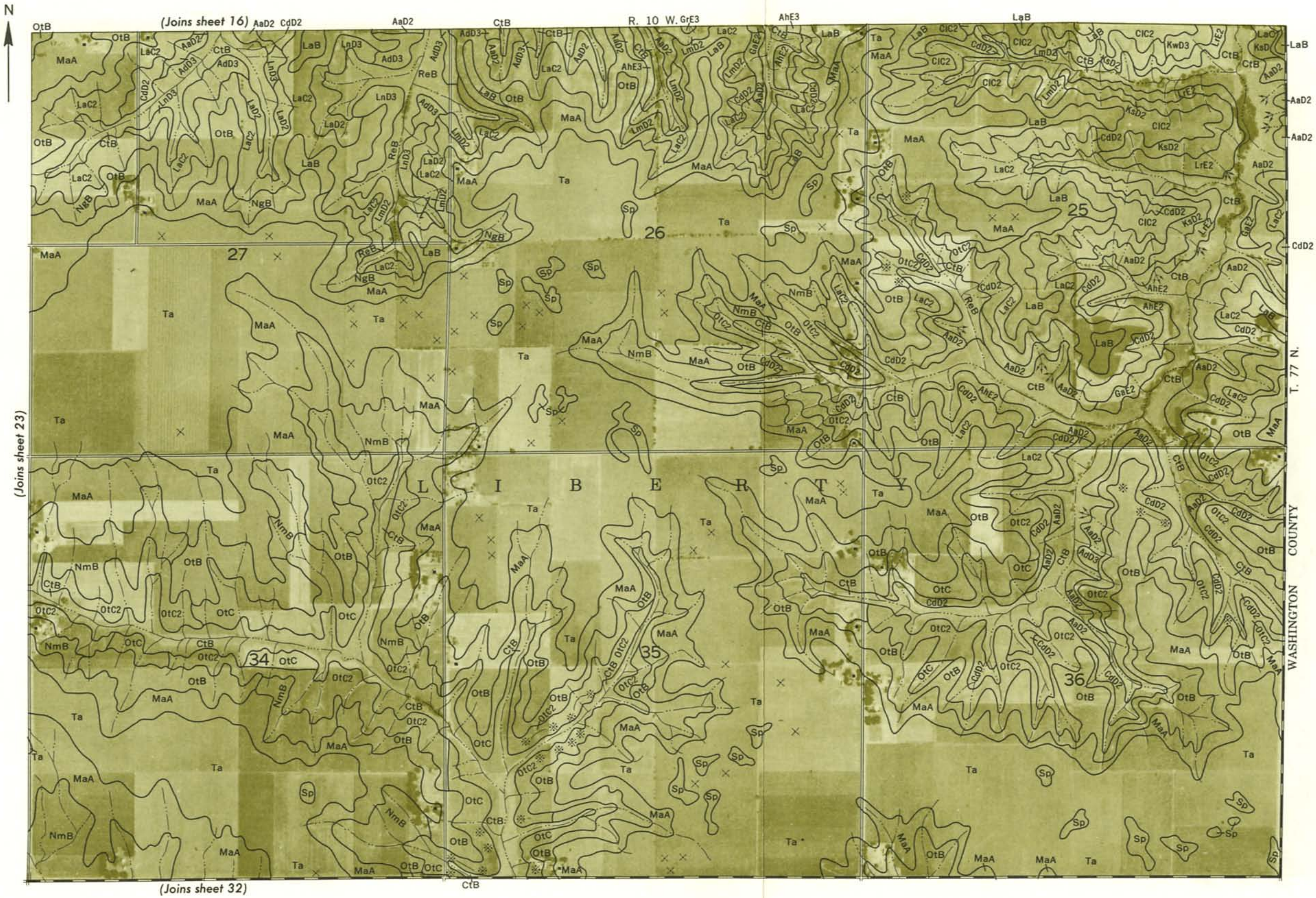

N
POWESHIEK COUNTY
R. 13 W.
T. 77 N.
(Joins sheet 1)
(Joins sheet 3)
(Joins sheet 10)
P R A I R I E
South English River
1
2
3
10
11
12
21


N
(Joins sheet 12)
R. 12 W.
T. 77 N.
(Joins sheet 19)
(Joins sheet 21)
(Joins sheet 28)
CHICAGO ROCK ISLAND AND PACIFIC
A D A M S
27
26
25
34
35
36
22


N
R. 11 W.
T. 77 N.
(Joins sheet 13)
(Joins sheet 20)
(Joins sheet 22)
(Joins sheet 29)
Webster
ENGLISH RIVER
CHICAGO ROCK ISLAND AND PACIFIC
CHICAGO MILWAUKEE ST PAUL AND PACIFIC
German Creek
28
29
30
31
32
33
149
22

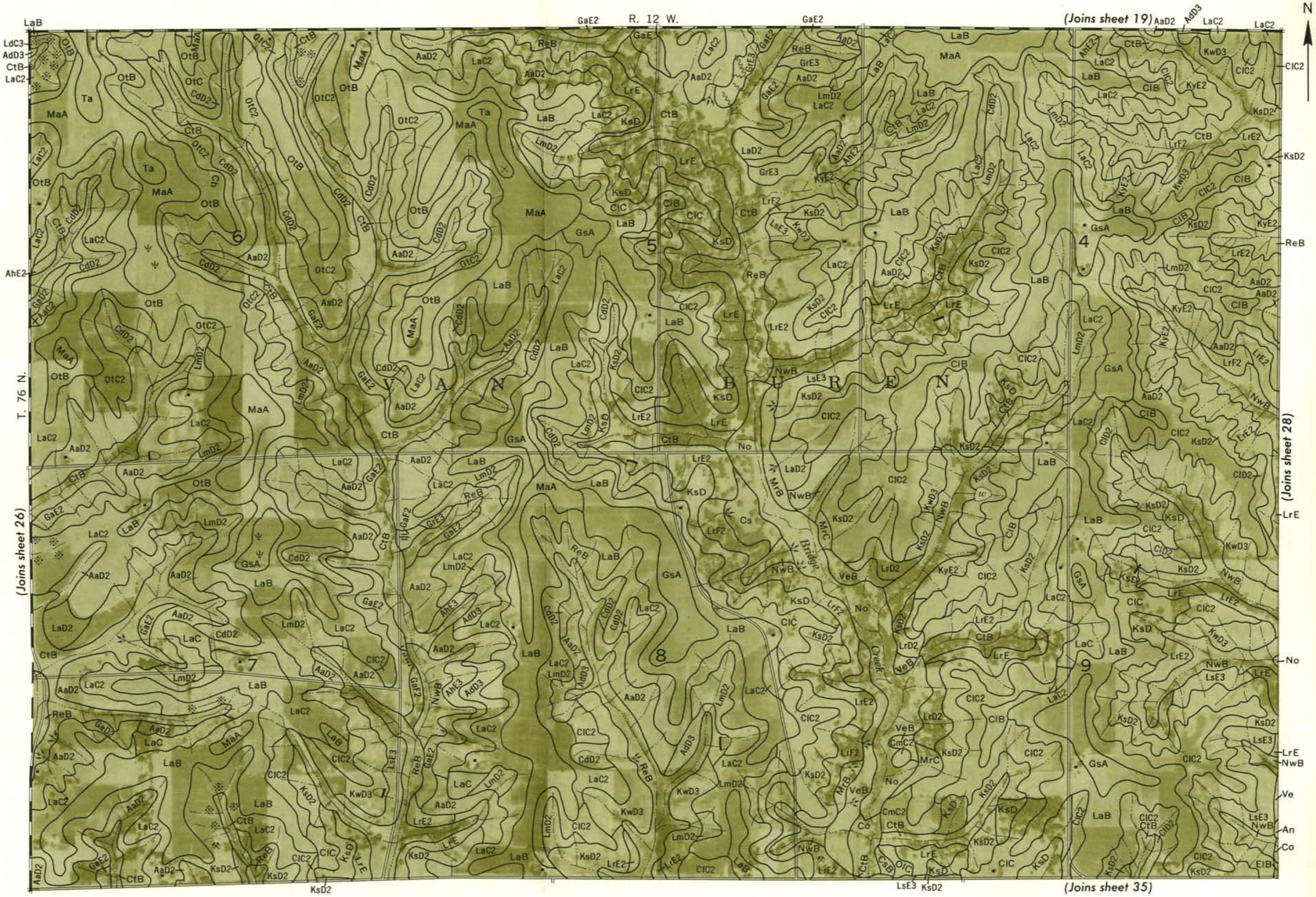

N
(Joins sheet 14)
R. 11 W.
South English
CHICAGO ROCK ISLAND AND PACIFIC
GRAVEL PIT
E N G L I S H R I V E R
Troublesome Creek
T. 77 N.
(Joins sheet 21)
(Joins sheet 23)
(Joins sheet 30)
27
26
25
34
35
36

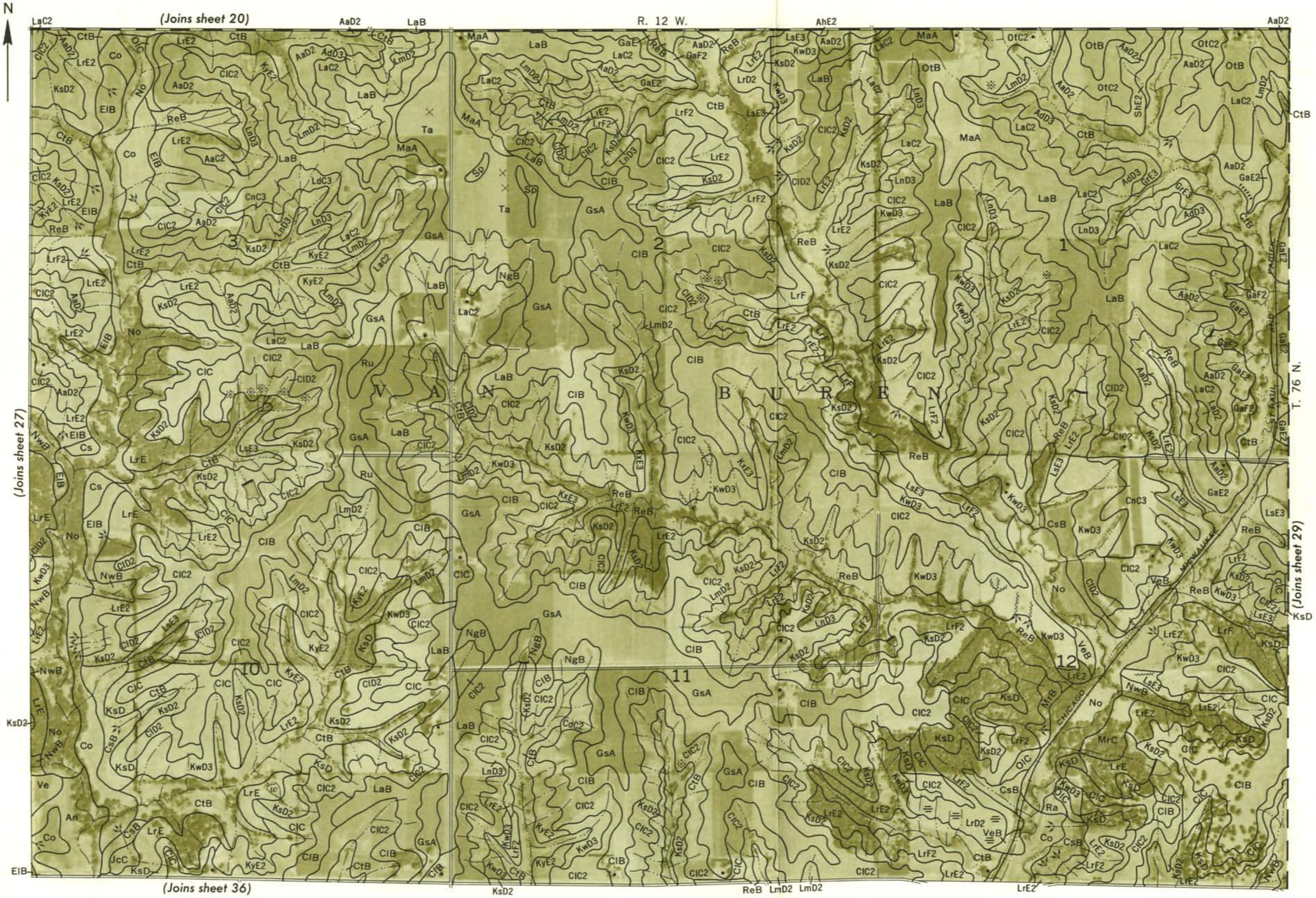

N
R. 10 W.
(Joins sheet 15)
(Joins sheet 24)
(Joins sheet 31)
(Joins sheet 22)
T. 77 N.
22
30
29
28
31
32
33
L I B E R T Y
Smith Creek
CHICAGO ROCK ISLAND AND PACIFIC
Mennonite Church
AaD2
LaC2
LaC2
CdC2


N
(Joins sheet 16)
R. 10 W.
T. 77 N.
WASHINGTON COUNTY
(Joins sheet 23)
(Joins sheet 32)
L I B E R T Y
25
26
27
34
35
36


N
R. 13 W.
(Joins sheet 17)
(Joins sheet 26)
(Joins sheet 33)
T. 76 N.
MAHASKA COUNTY
W A S H I N G T O N
COAL MINE DUMP
COAL MINE DUMP
DUMP
INDUSTRIAL SITE
Creek
What Cheer
4
5
6
7
8
9
21
21

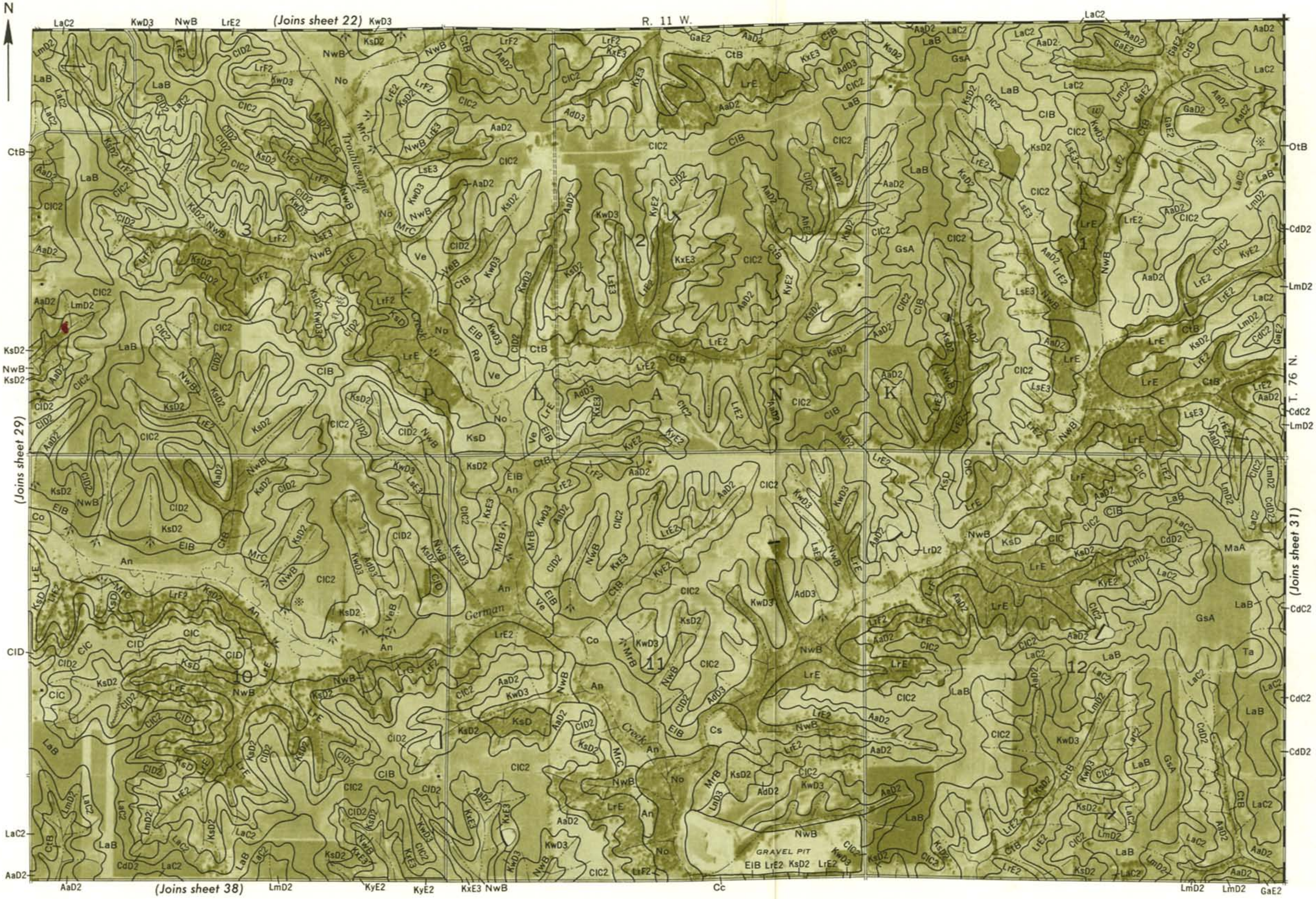
KEOKUK COUNTY, IOWA — SHEET NUMBER 26

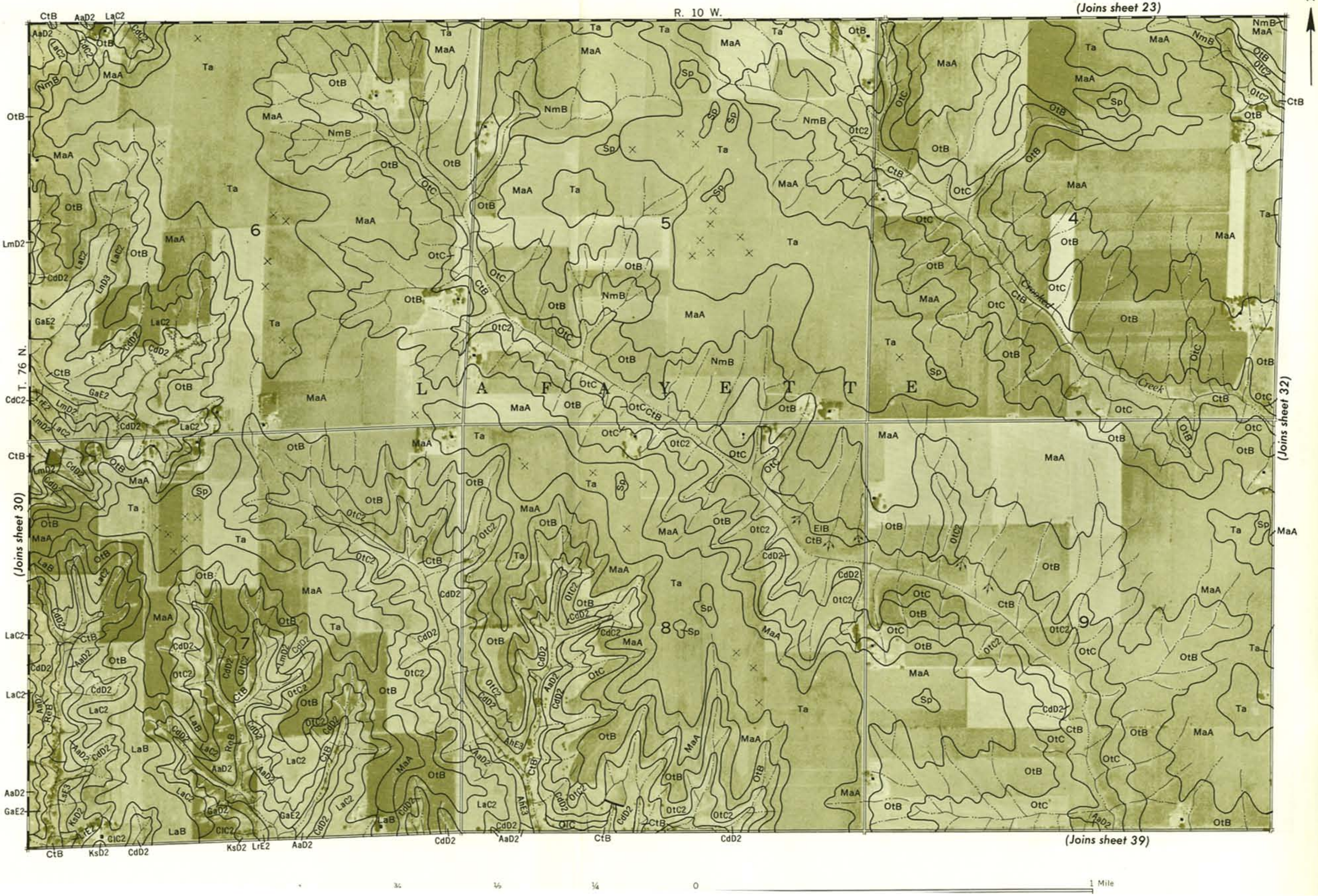

R. 12 W.
(Joins sheet 19)
N
T. 76 N.
(Joins sheet 26)
(Joins sheet 28)
(Joins sheet 35)
V A N B U R E N
Bridge Creek

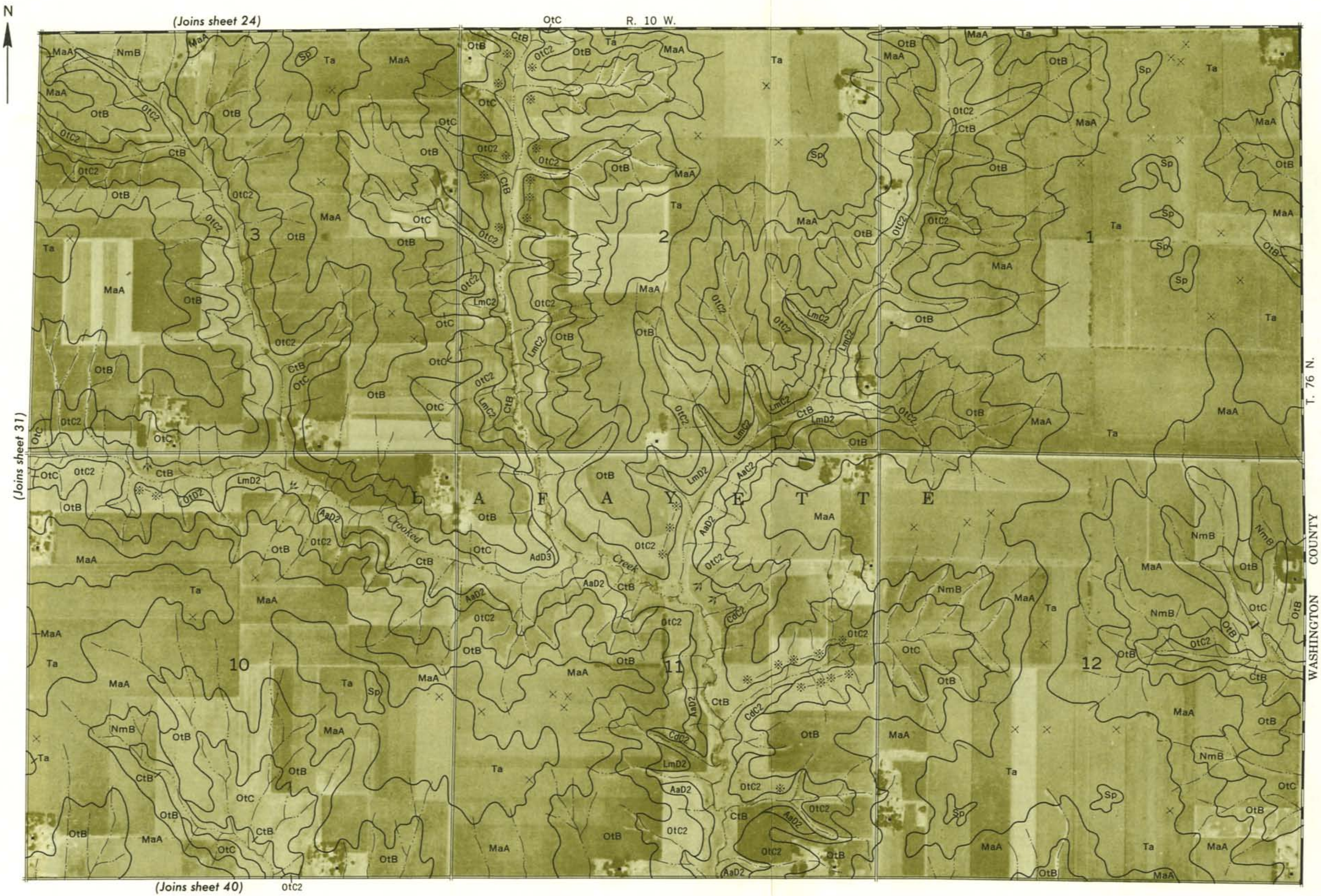

N
(Joins sheet 20)
R. 12 W.
(Joins sheet 27)
(Joins sheet 29)
(Joins sheet 36)
T. 76 N.
VAN BUREN
1
2
3
10
11
12
CHICAGO
MILWAUKEE
PACIFIC

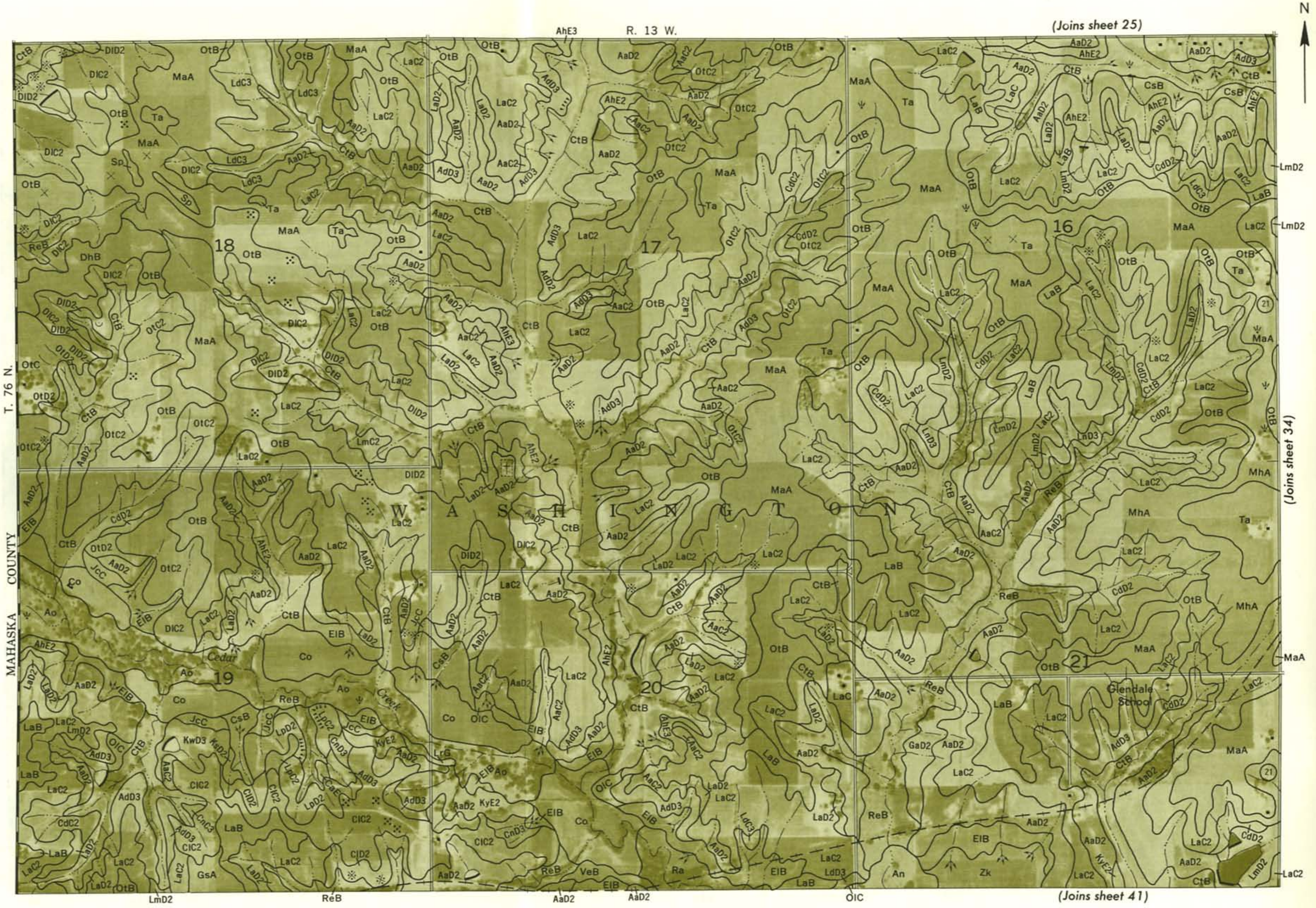

(Joins sheet 21)
R. 11 W.
N
T. 76 N.
(Joins sheet 28)
(Joins sheet 30)
(Joins sheet 37)
P L A N K
6
5
4
7
8
9
Germany Creek

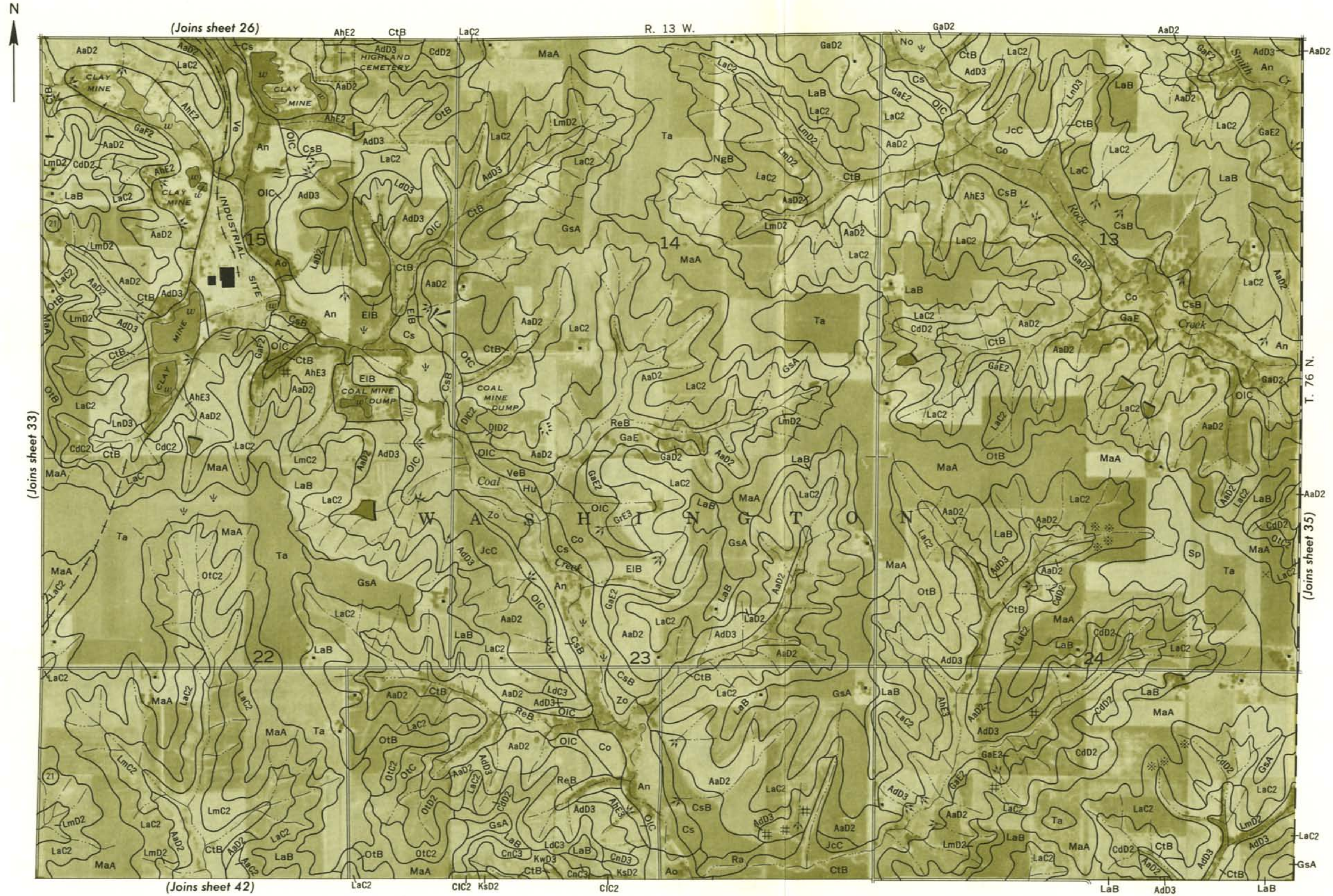

N
R. 12 W.
IOWA COUNTY
T. 77 N.
A D A M S
(Joins sheet 2)
(Joins sheet 4)
(Joins sheet 11)
6
5
4
7
8
9


N
(Joins sheet 22)
R. 11 W.
T. 76 N.
(Joins sheet 29)
(Joins sheet 31)
(Joins sheet 38)
Troublesome Creek
German Creek
P L A N K
GRAVEL PIT
1
2
3
10
11
12


R. 10 W.
(Joins sheet 23)
N
(Joins sheet 30)
(Joins sheet 32)
(Joins sheet 39)
T. 76 N.
L A F A Y E T T E
Crooked Creek
6
5
4
7
8
9
3/4
1/2
1/4
0
1 Mile


N
(Joins sheet 24)
R. 10 W.
T. 76 N.
(Joins sheet 31)
WASHINGTON COUNTY
(Joins sheet 40)
L A F A Y E T T E
Crooked Creek
1
2
3
10
11
12

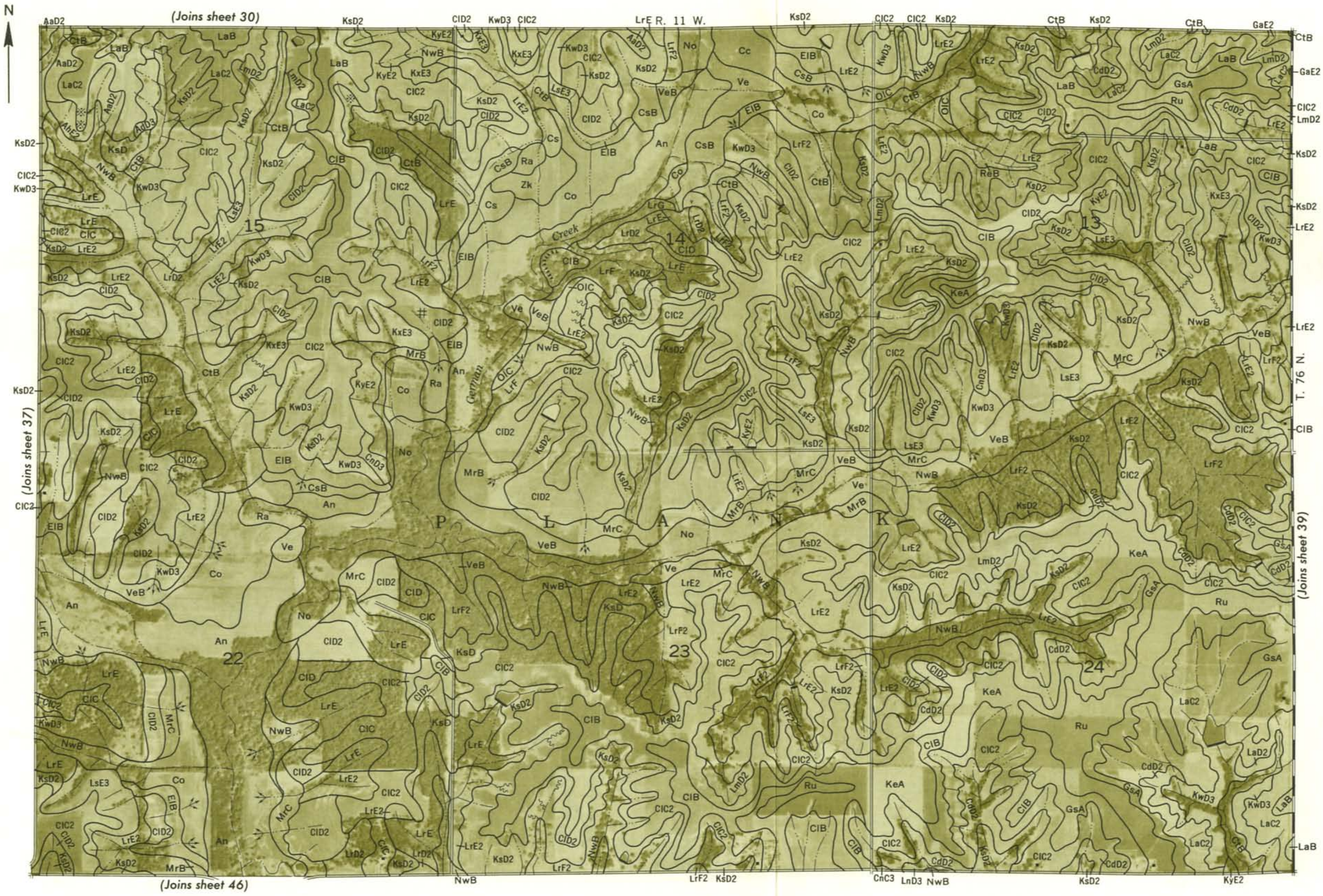

N
(Joins sheet 25)
R. 13 W.
T. 76 N.
MAHASKA COUNTY
(Joins sheet 34)
(Joins sheet 41)
W A S H I N G T O N
Cedar
Creek
Glendale School
16
17
18
19
20
21

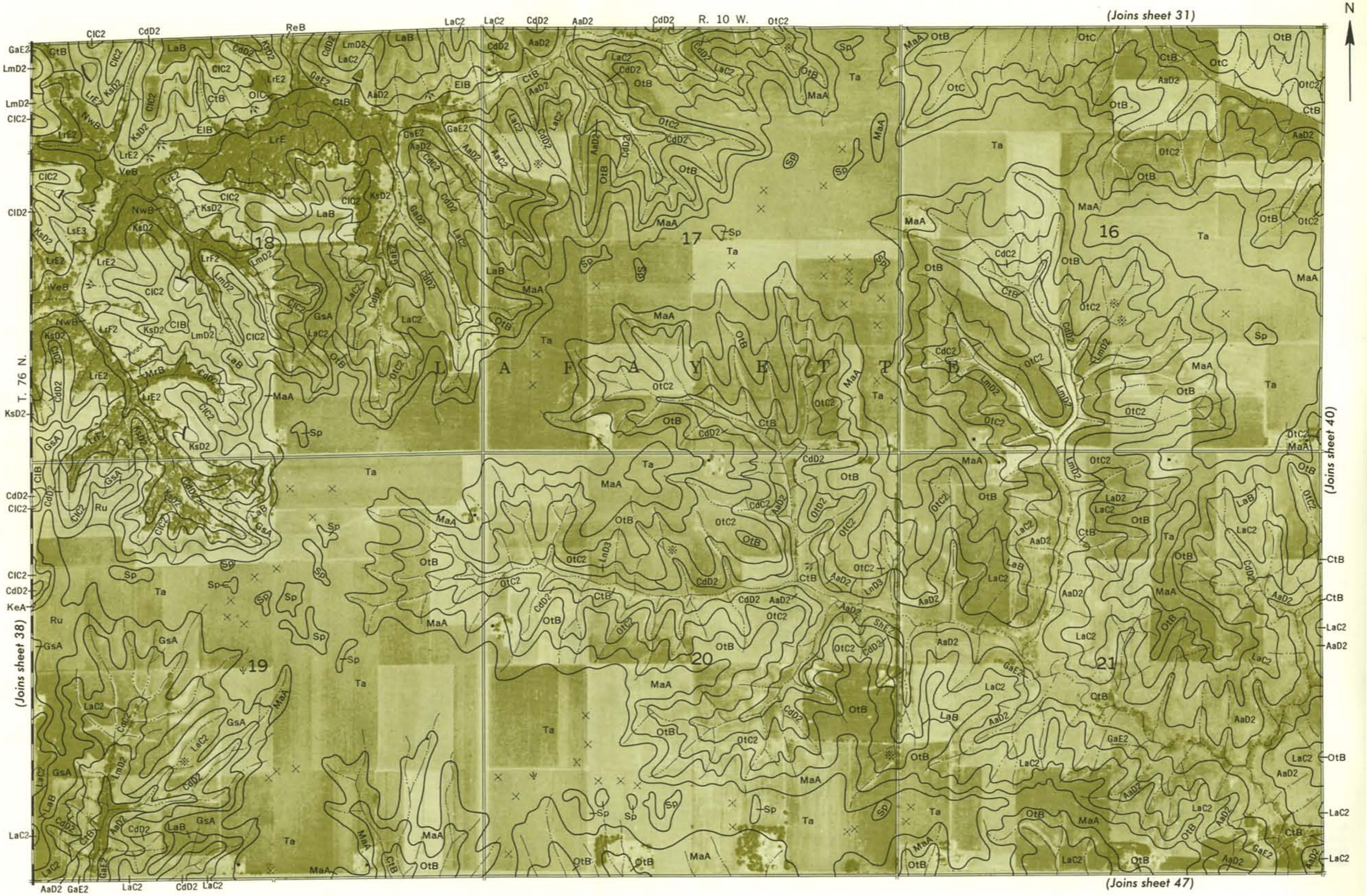

N
(Joins sheet 26)
R. 13 W.
T. 76 N.
(Joins sheet 33)
(Joins sheet 35)
(Joins sheet 42)
HIGHLAND CEMETERY
CLAY MINE
INDUSTRIAL SITE
COAL MINE DUMP
Smith Cr
Rock Creek
Coal Creek
W A S H I N G T O N
13
14
15
22
23
24
21

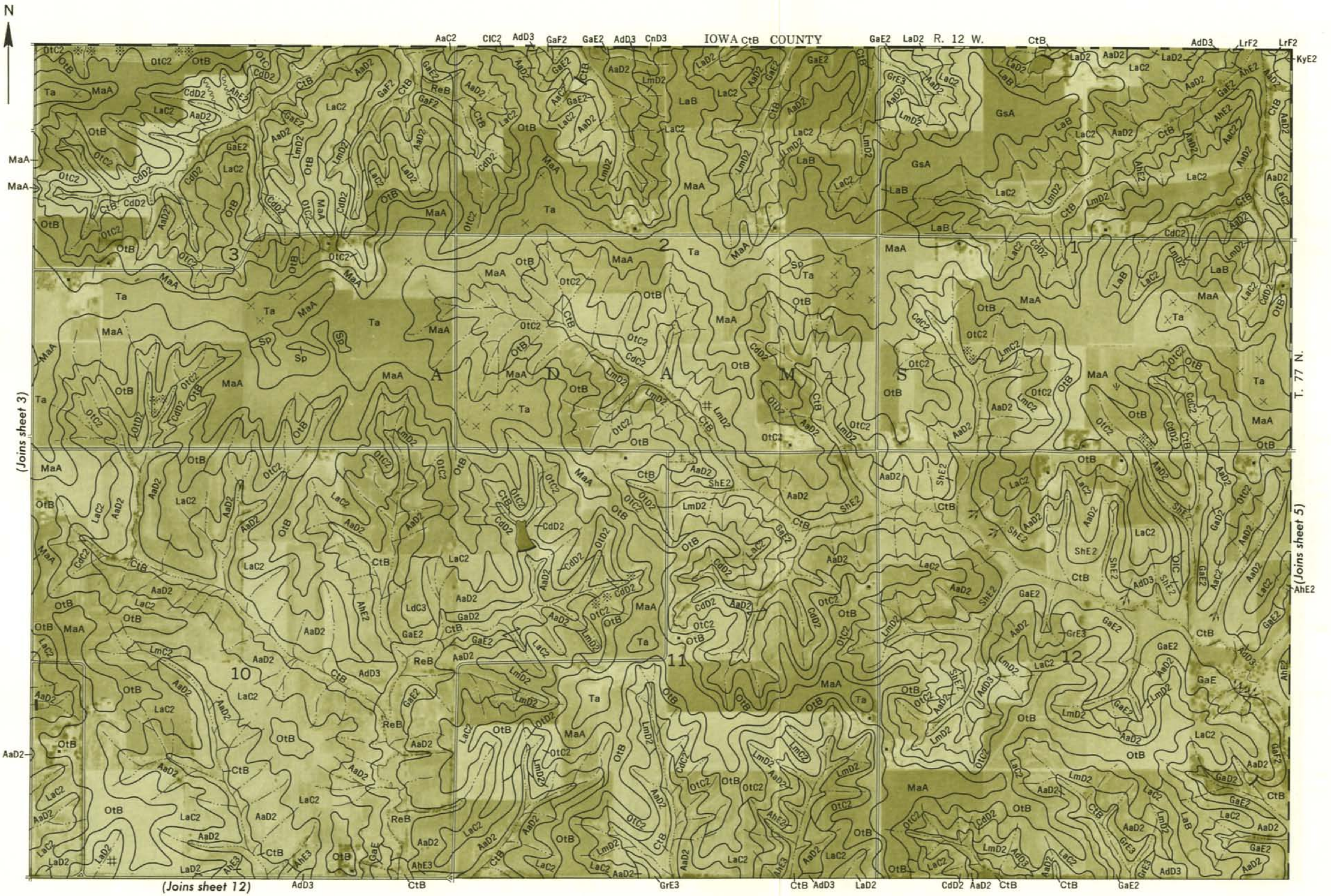

N
R. 12 W.
T. 76 N.
(Joins sheet 27)
(Joins sheet 34)
(Joins sheet 36)
(Joins sheet 43)
V A N B U R E N
Smith Creek
Rock Creek
Bridge Creek
16
17
18
19
20
21


N
(Joins sheet 28)
R. 12 W.
(Joins sheet 35)
(Joins sheet 37)
(Joins sheet 44)
T. 76 N.
V A N B U R E N
15
14
13
22
23
24
QUARRY
LIMESTONE QUARRY
Lake Yenruogis
SIG-NOR AIRPORT
CITY DUMP
Bridge Creek
CHICAGO MILWAUKEE ST PAUL AND PACIFIC
149


(Joins sheet 29)
N
R. 11 W.
T. 76 N.
(Joins sheet 36)
(Joins sheet 38)
(Joins sheet 45)
16
17
18
19
20
21
P L A N K
149


N
(Joins sheet 30)
R. 11 W.
T. 76 N.
(Joins sheet 37)
(Joins sheet 39)
(Joins sheet 46)
German
Creek
P L A N K
15
14
13
22
23
24


(Joins sheet 31)
R. 10 W.
N
T. 76 N.
(Joins sheet 38)
(Joins sheet 40)
(Joins sheet 47)
L A F A Y E T T E
18
17
16
19
20
21


N
IOWA COUNTY
R. 12 W.
T. 77 N.
A D A M S
1
2
3
10
11
12
(Joins sheet 3)
(Joins sheet 5)
(Joins sheet 12)


N
(Joins sheet 32)
R. 10 W.
(Joins sheet 39)
(Joins sheet 48)
T. 76 N.
WASHINGTON COUNTY
L A F A Y E T T E
LAFAYETTE CEMETERY
Crooked Creek
KEOTA
15
14
13
22
23
24

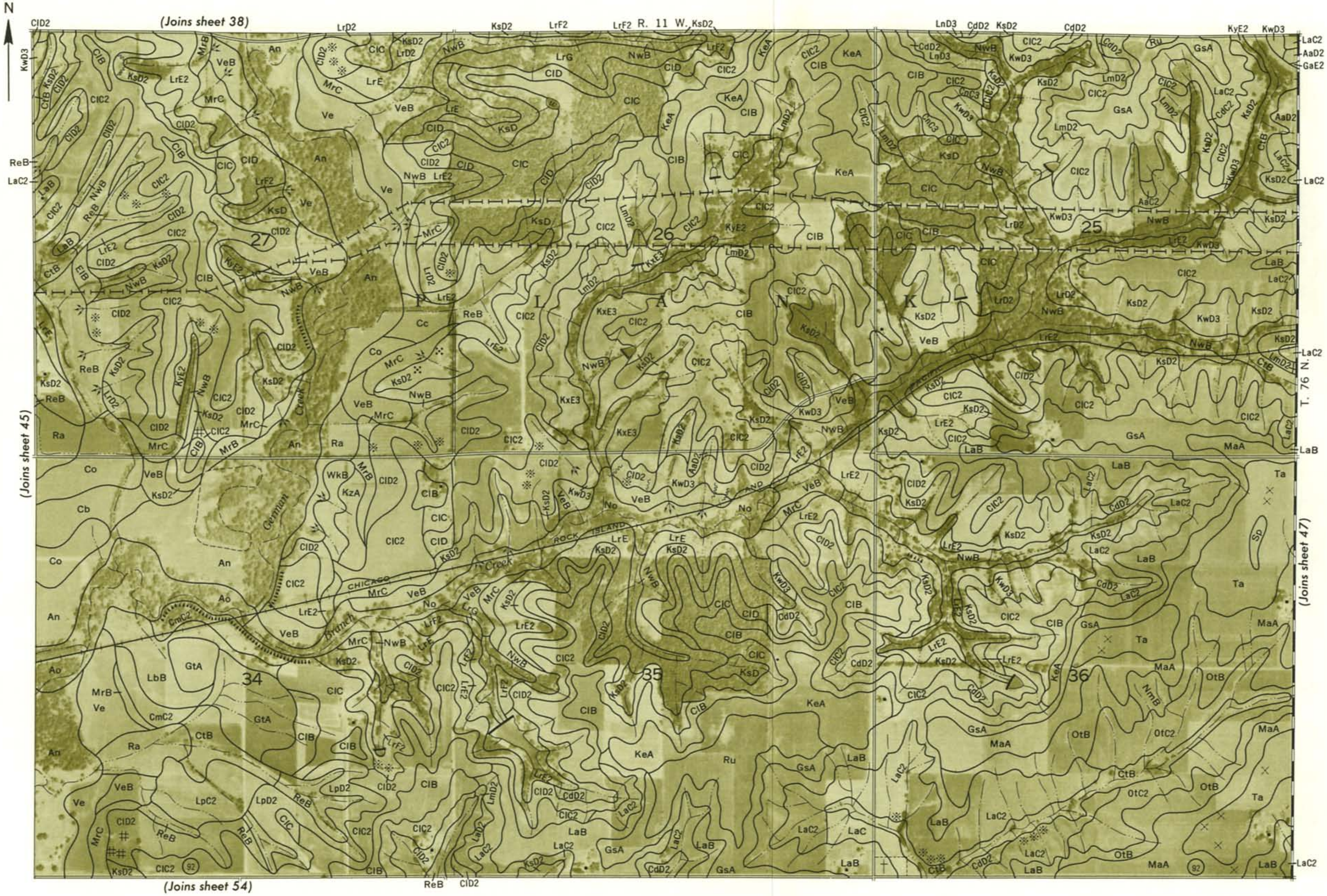

N
R. 13 W.
(Joins sheet 33)
(Joins sheet 42)
(Joins sheet 49)
T. 76 N.
MAHASKA COUNTY
W A S H I N G T O N
Cedar
Creek
28
29
30
31
32
33

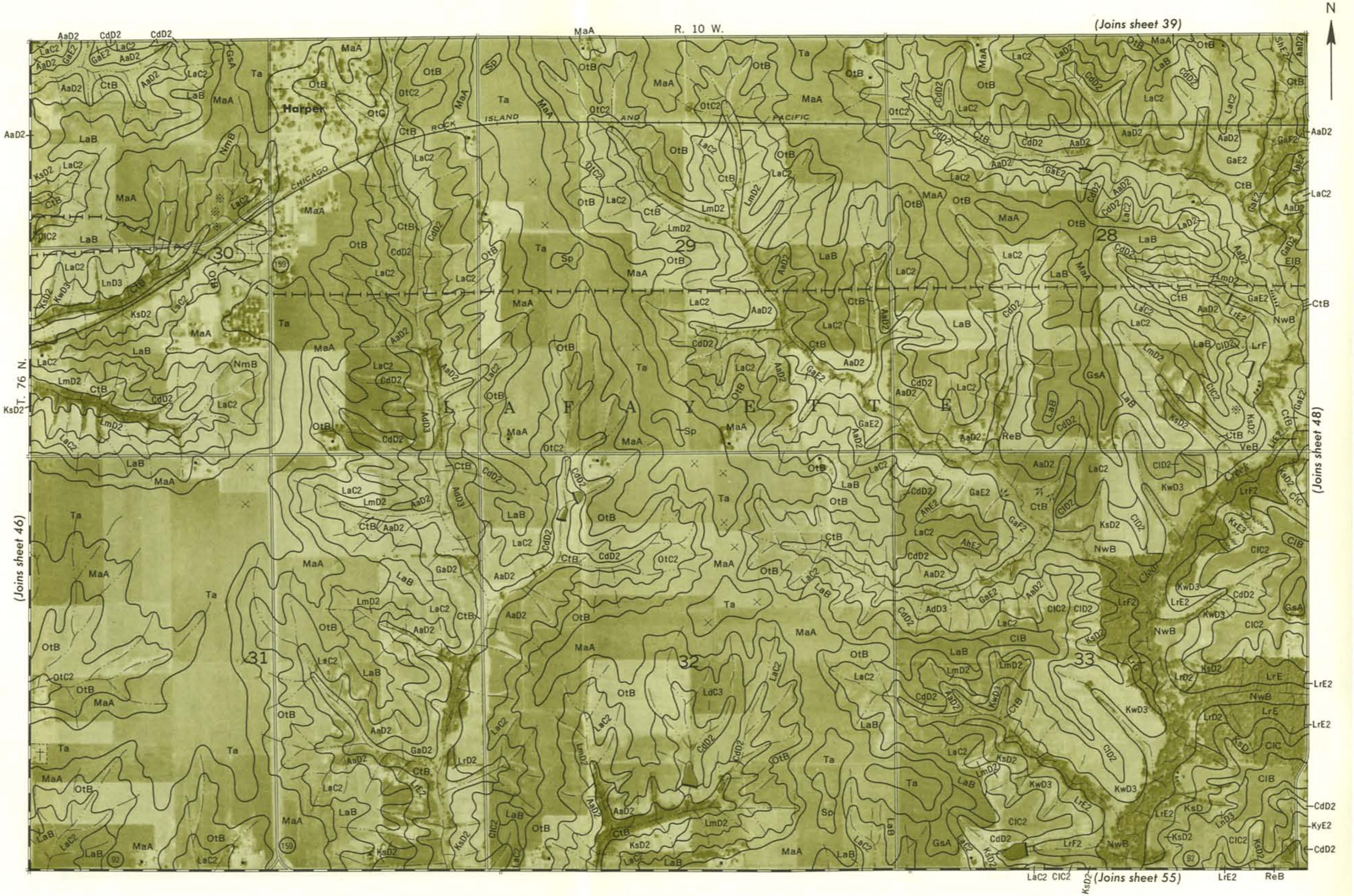

N
(Joins sheet 34)
R. 13 W.
(Joins sheet 41)
(Joins sheet 43)
T. 76 N.
(Joins sheet 50)
27
26
25
34
35
36
W A S H I N G T O N
Coal
Creek
Cedar
Creek
SPRINGFIELD CEMETERY
GARRETT CEMETERY

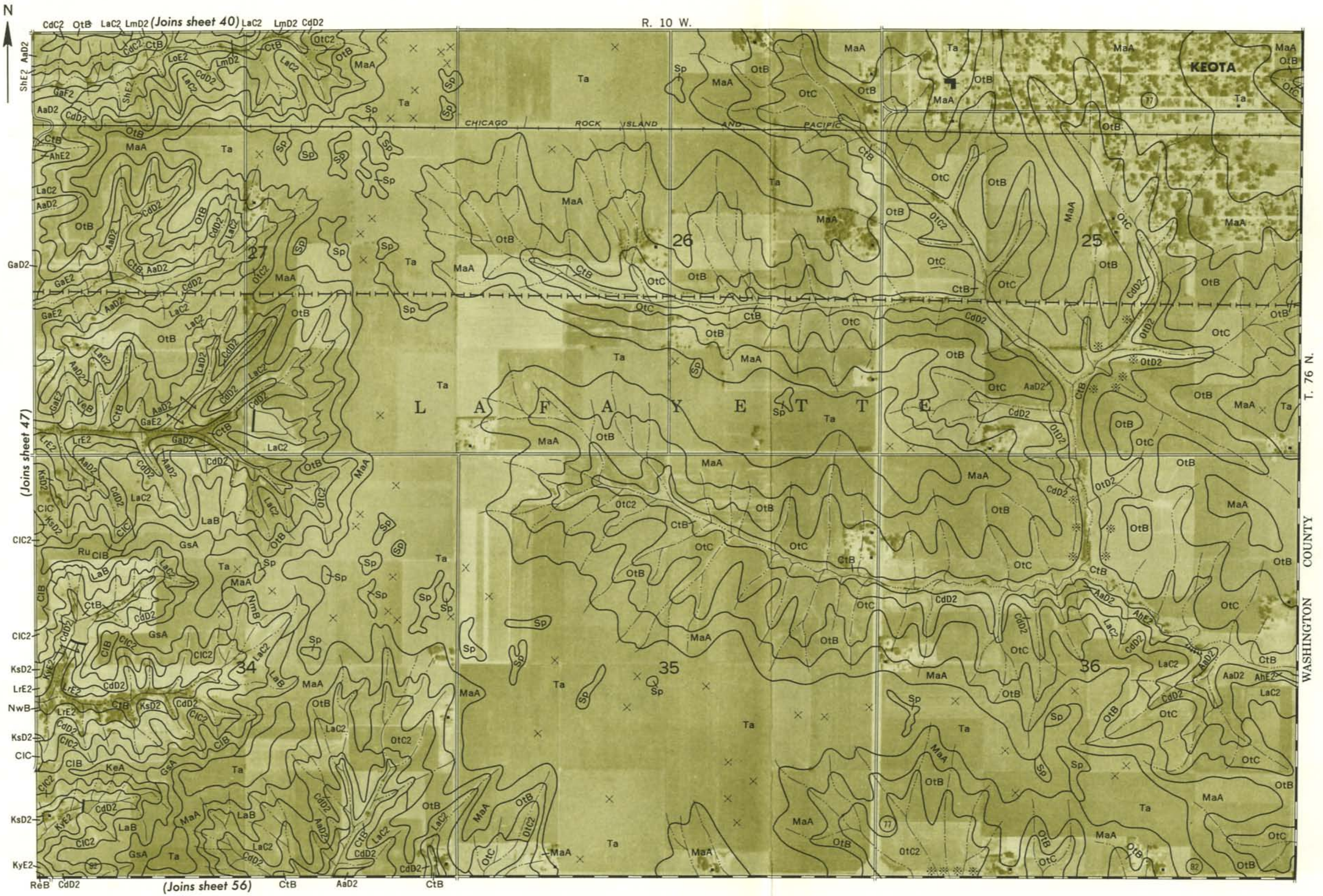

N
R. 12 W.
(Joins sheet 35)
(Joins sheet 44)
(Joins sheet 51)
(Joins sheet 42)
T. 76 N.
30
29
28
31
32
33
V A N B U R E N
Rock
Creek
White Oak
School

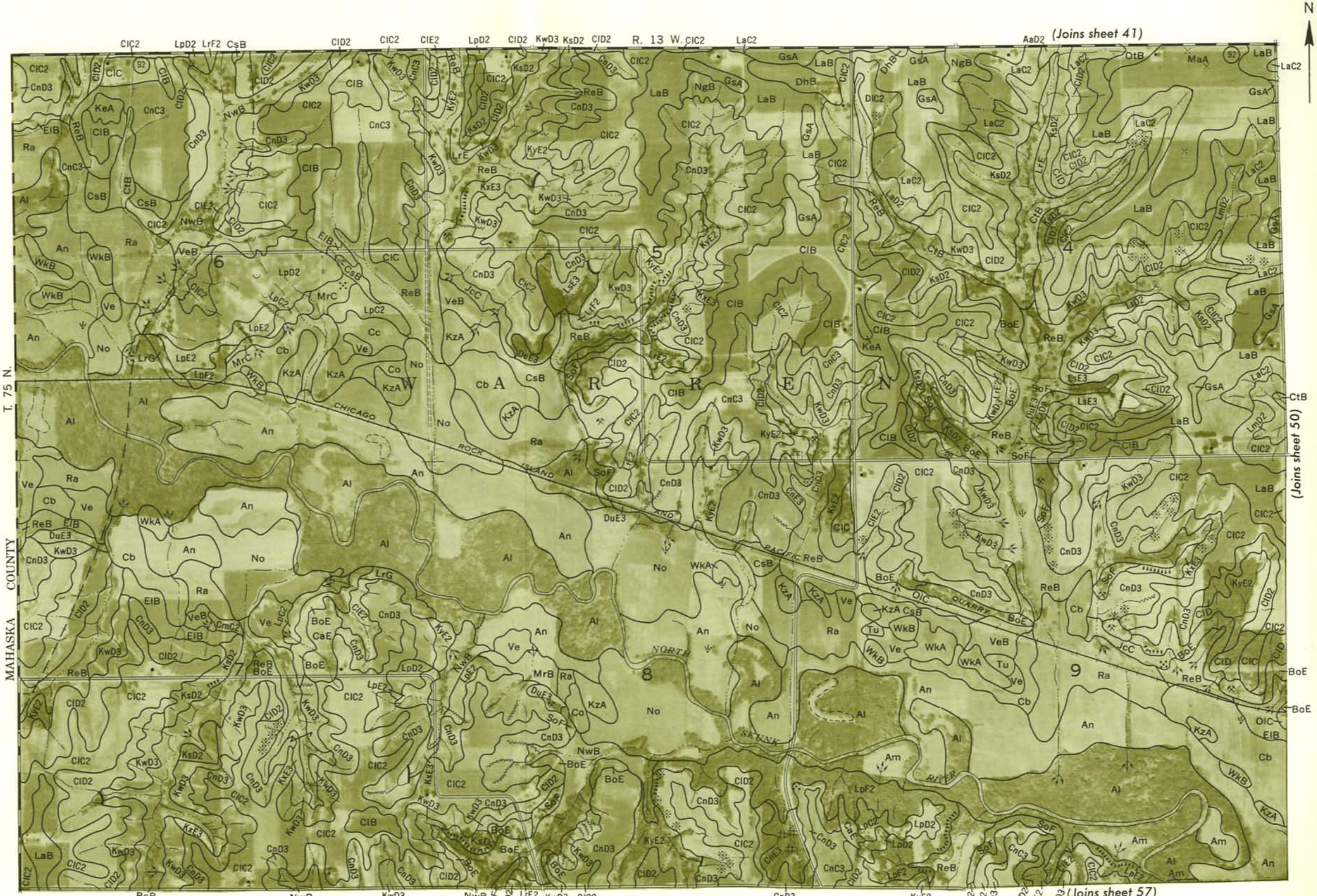

N
(Joins sheet 36)
R. 12 W.
T. 76 N.
(Joins sheet 43)
(Joins sheet 45)
(Joins sheet 52)
VAN BUREN
SIGOURNEY
27
26
25
34
35
36
CHICAGO MILWAUKEE ST. PAUL AND PACIFIC
CHICAGO ROCK ISLAND AND PACIFIC
Bridge
No Creek
Rock Creek
COUNTRY CLUB
PLEASANT GROVE CEMETERY
SIGOURNEY EAST CEMETERY
SIGOURNEY
149
92

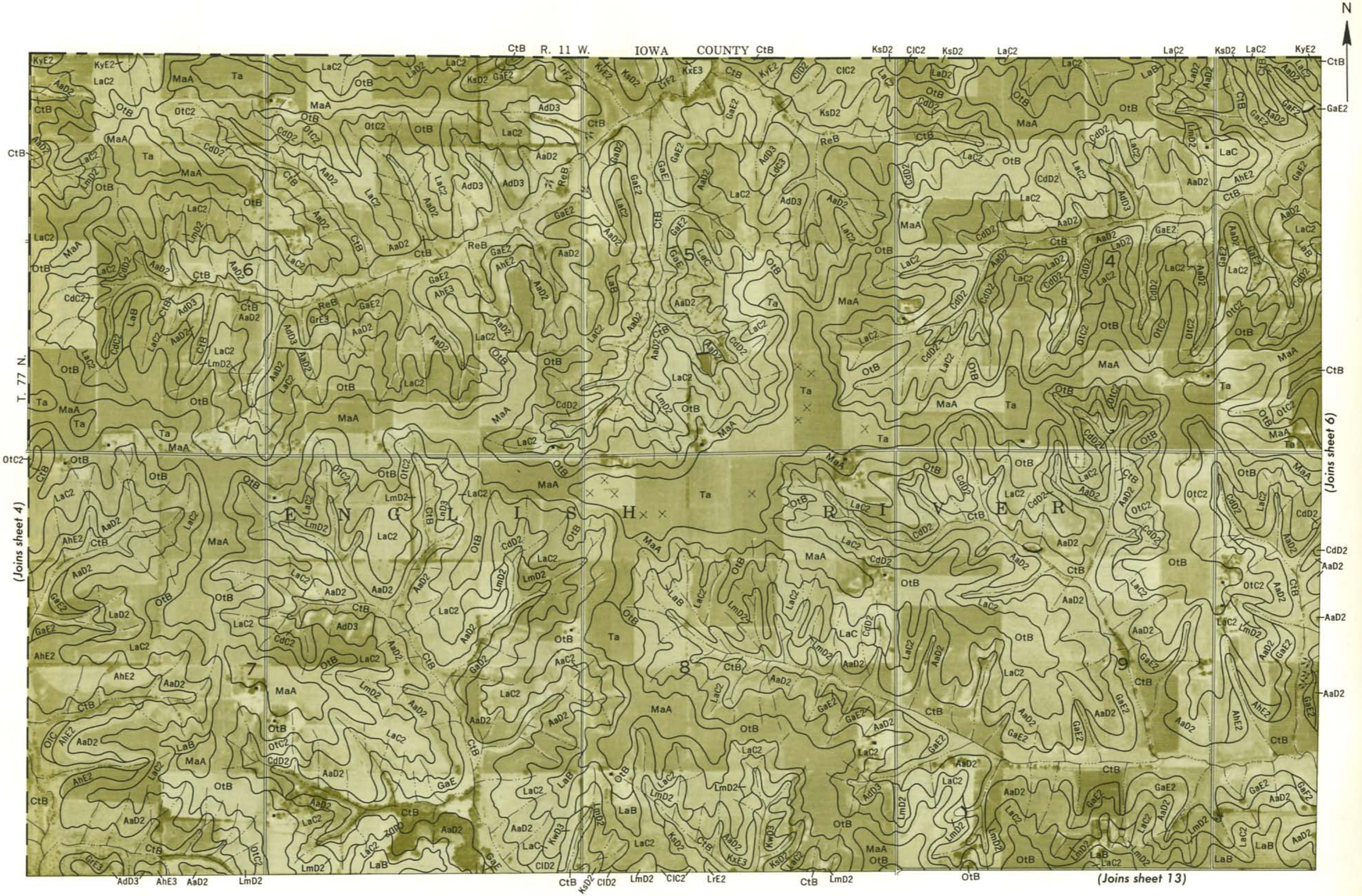

N
R. 11 W.
T. 76 N.
(Joins sheet 37)
(Joins sheet 44)
(Joins sheet 46)
(Joins sheet 53)
PLANK
30
29
28
31
32
33
CHICAGO ROCK ISLAND AND PACIFIC
German Creek

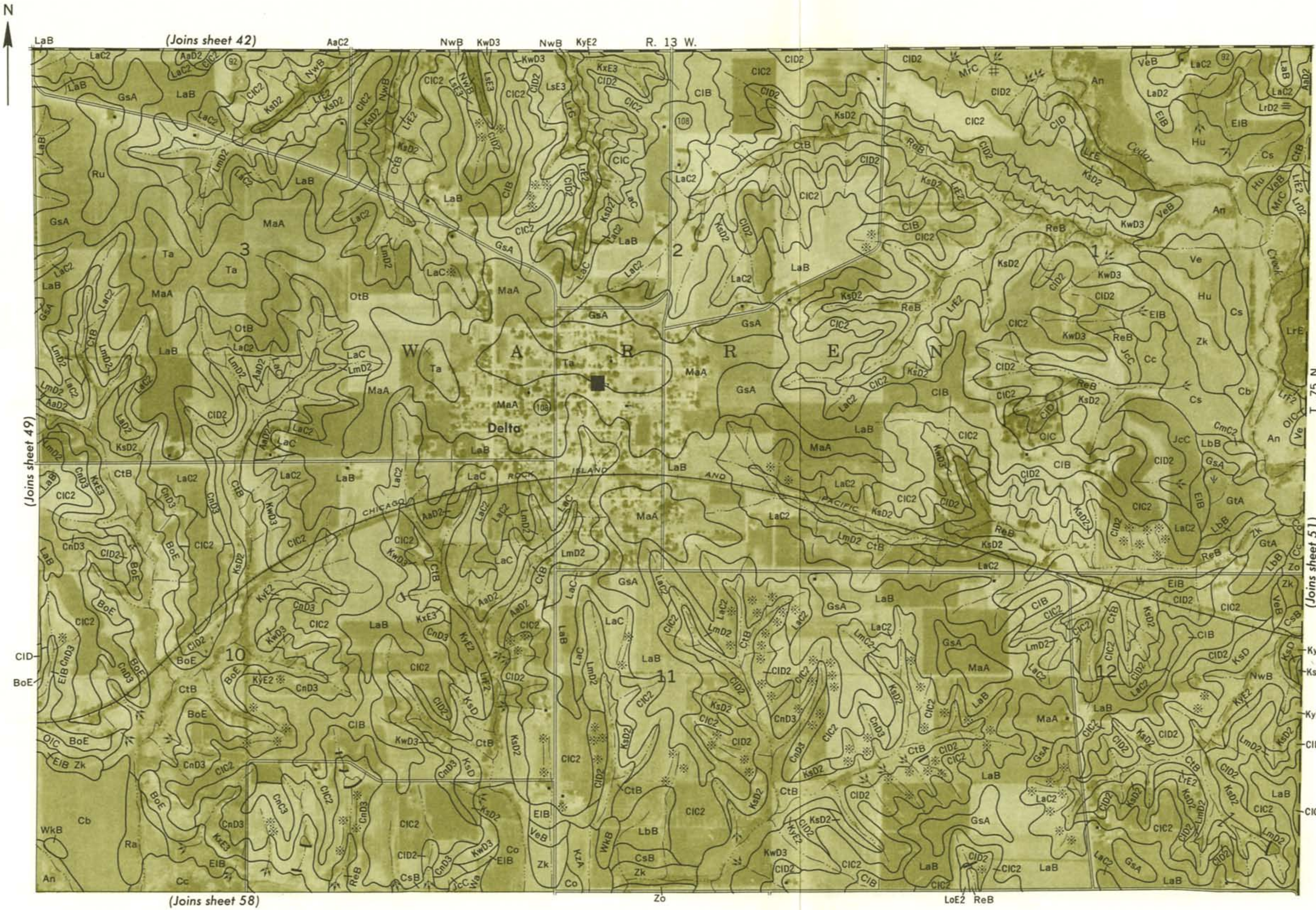

N
(Joins sheet 38)
R. 11 W.
T. 76 N.
(Joins sheet 45)
(Joins sheet 47)
(Joins sheet 54)
P L A N K
27
26
25
34
35
36
Creek
German
Creek
Branch
CHICAGO
ROCK ISLAND
AND
92
92

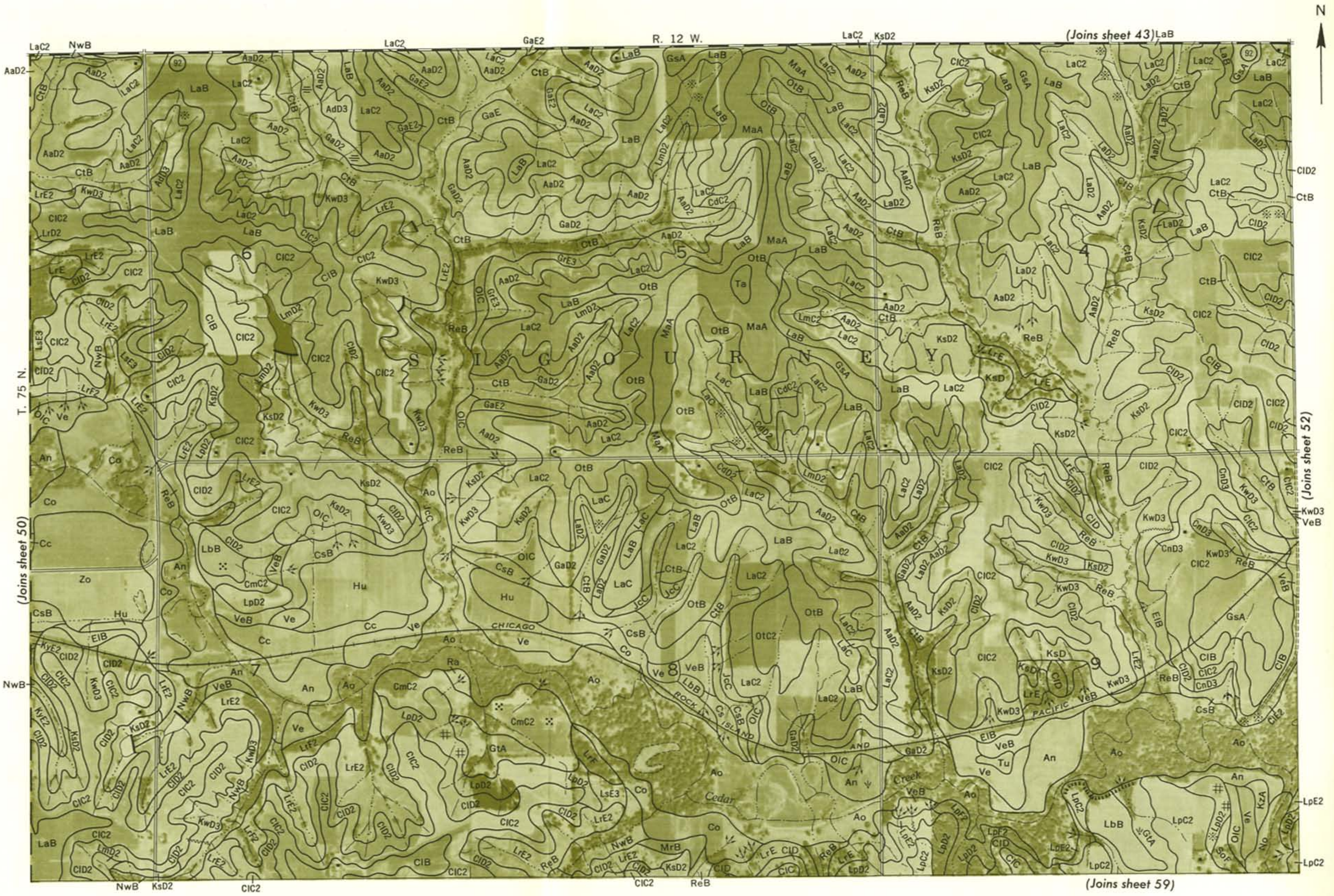

N
R. 10 W.
(Joins sheet 39)
(Joins sheet 46)
(Joins sheet 48)
(Joins sheet 55)
T. 76 N.
Harper
CHICAGO
ROCK
ISLAND
AND
PACIFIC
L A F A Y E T T E
Creek
Clear
28
29
30
31
32
33
159
92
AaD2
CdD2
MaA
AaD2
LaC2
KsD2
CtB
LrE2
CdD2
KyE2
LaC2
ClC2
KsD2
LrE2
ReB


N
(Joins sheet 40)
R. 10 W.
KEOTA
CHICAGO ROCK ISLAND AND PACIFIC
27
26
25
L A F A Y E T T E
34
35
36
T. 76 N.
WASHINGTON COUNTY
(Joins sheet 47)
(Joins sheet 56)


N
(Joins sheet 41)
R. 13 W.
T. 75 N.
MAHASKA COUNTY
(Joins sheet 50)
(Joins sheet 57)
WARREN
CHICAGO ROCK ISLAND AND PACIFIC
NORTH SKUNK RIVER
QUARRY
92
4
5
6
7
8
9


N
R. 11 W.
IOWA COUNTY
T. 77 N.
E N G L I S H R I V E R
(Joins sheet 4)
(Joins sheet 6)
(Joins sheet 13)


N
(Joins sheet 42)
R. 13 W.
T. 75 N.
(Joins sheet 49)
(Joins sheet 51)
(Joins sheet 58)
W A R R E N
Delta
CHICAGO ROCK ISLAND AND PACIFIC
Cedar
Creek
1
2
3
10
11
12


N
R. 12 W.
T. 75 N.
(Joins sheet 43)
(Joins sheet 52)
(Joins sheet 59)
(Joins sheet 50)
S I G O U R N E Y
CHICAGO
ROCK ISLAND
AND
PACIFIC
Cedar
Creek

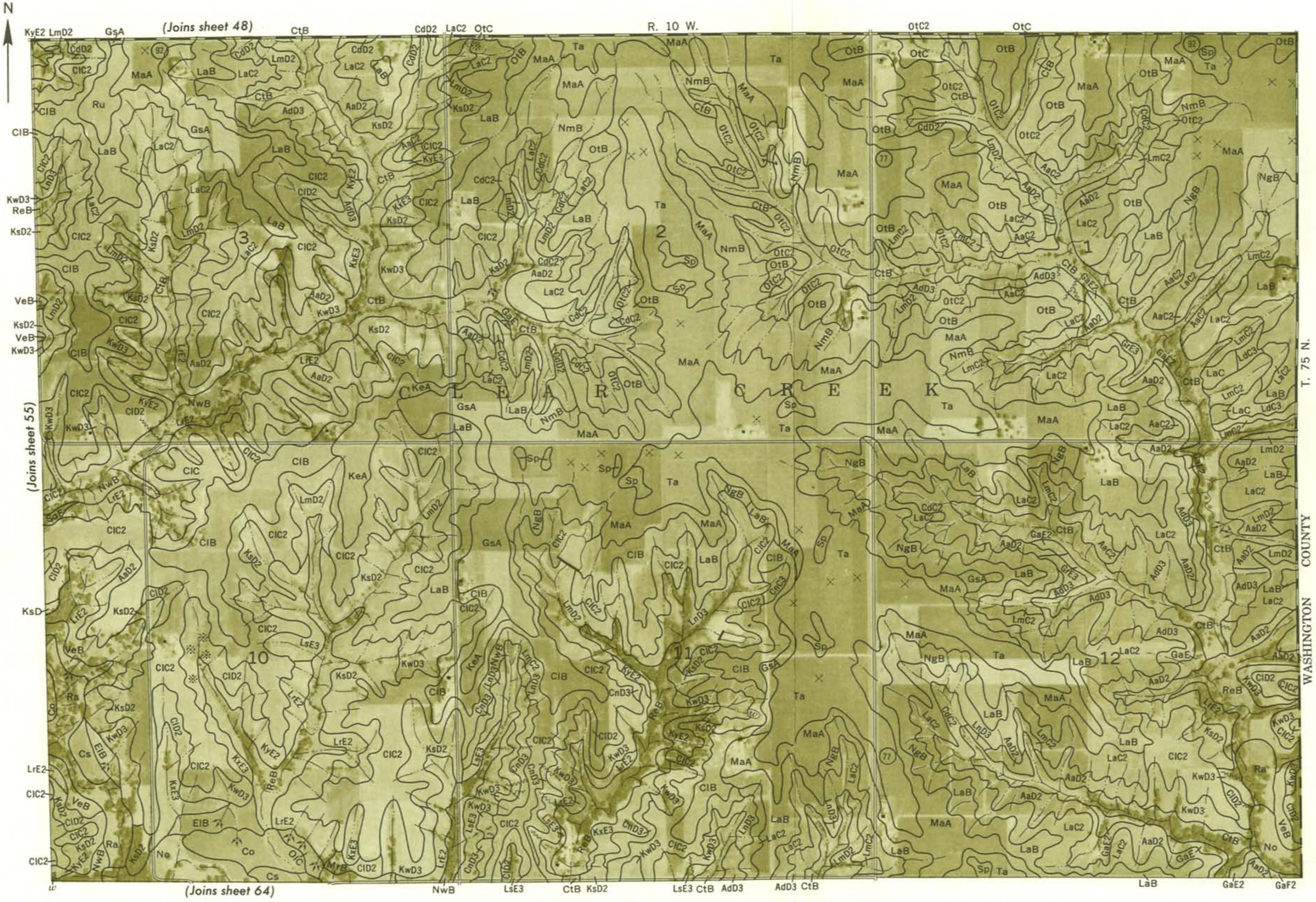

N
(Joins sheet 44)
R. 12 W.
(Joins sheet 51)
(Joins sheet 53)
(Joins sheet 60)
T. 75 N.
SIGOURNEY
S I G O U R N E Y
SEWAGE DISPOSAL
CHICAGO ROCK ISLAND AND PACIFIC
CHICAGO MILWAUKEE ST PAUL AND PACIFIC
Rock Creek
Cedar Creek
1
2
3
10
11
12

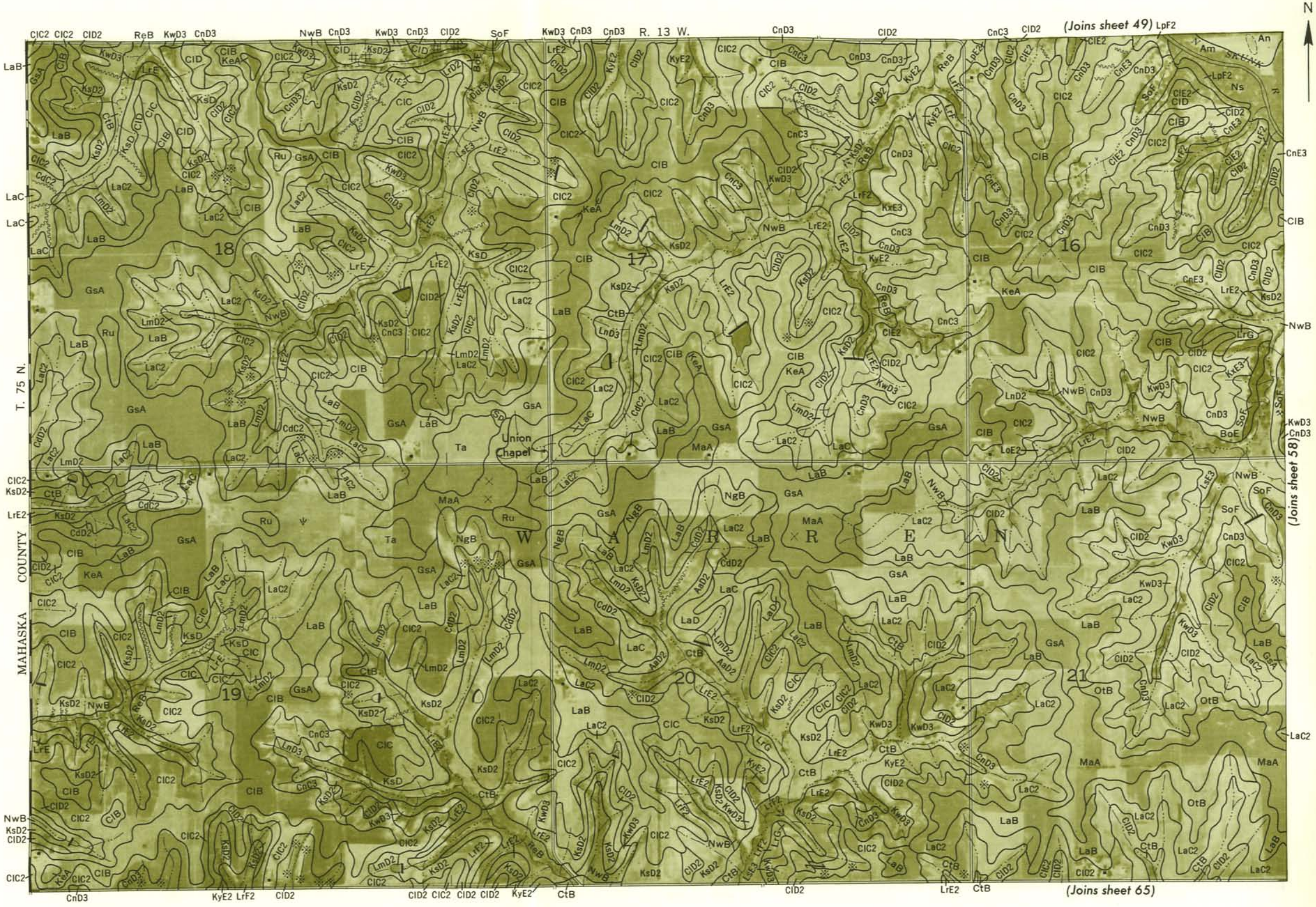
N

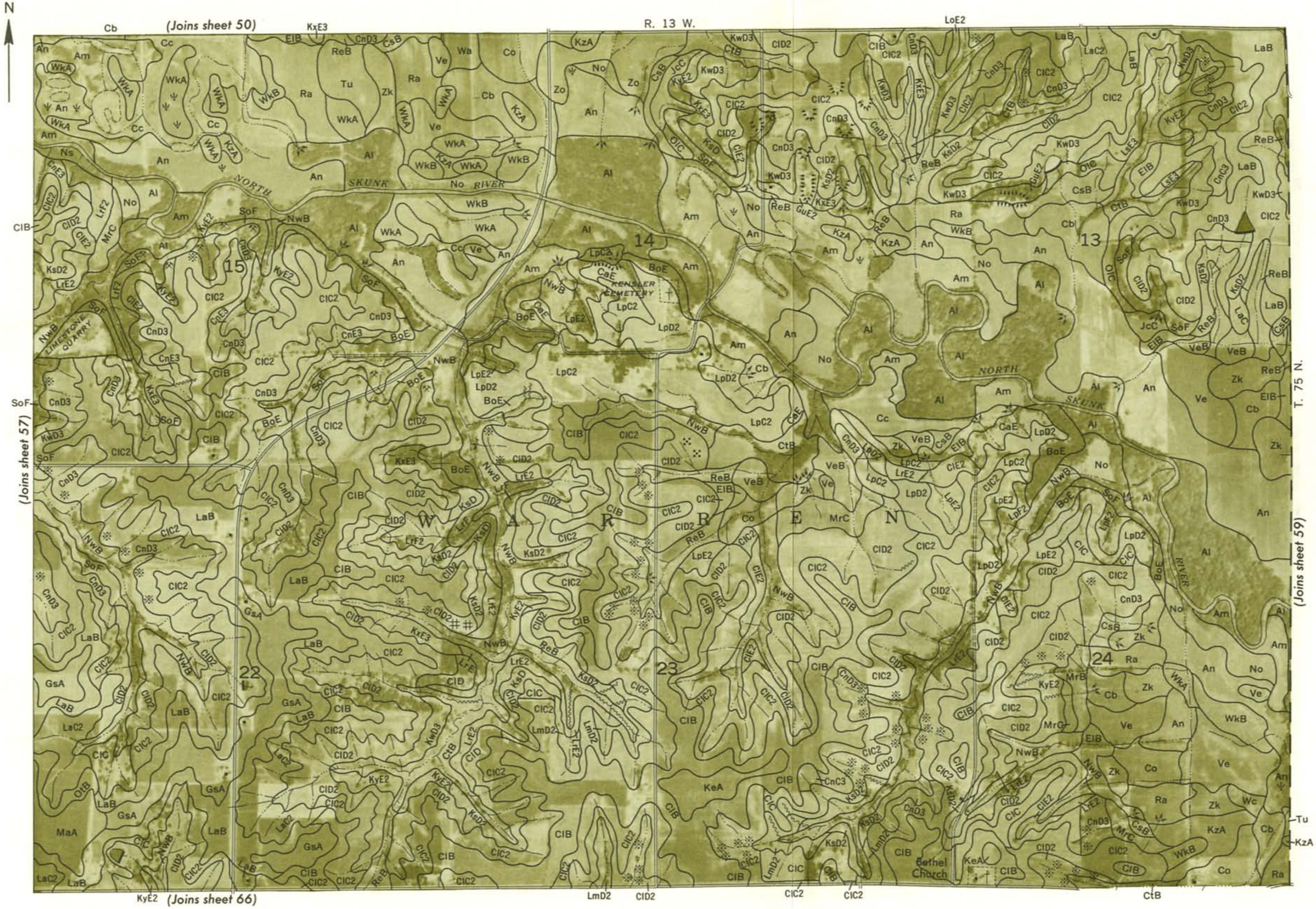

R. 11 W.
(Joins sheet 45)
(Joins sheet 52)
(Joins sheet 54)
(Joins sheet 61)
T. 75 N.
P L A N K
Bridge Creek
German Creek
4
5
6
7
8
9
92


N
(Joins sheet 46)
R. 11 W.
Bethel Church
T. 75 N.
(Joins sheet 53)
(Joins sheet 55)
(Joins sheet 62)
P L A N K
German Creek
1
2
3
10
11
12


R. 10 W.
(Joins sheet 47)
(Joins sheet 54)
(Joins sheet 56)
(Joins sheet 63)
T. 75 N.
N
CLEAR CREEK
Clear Creek

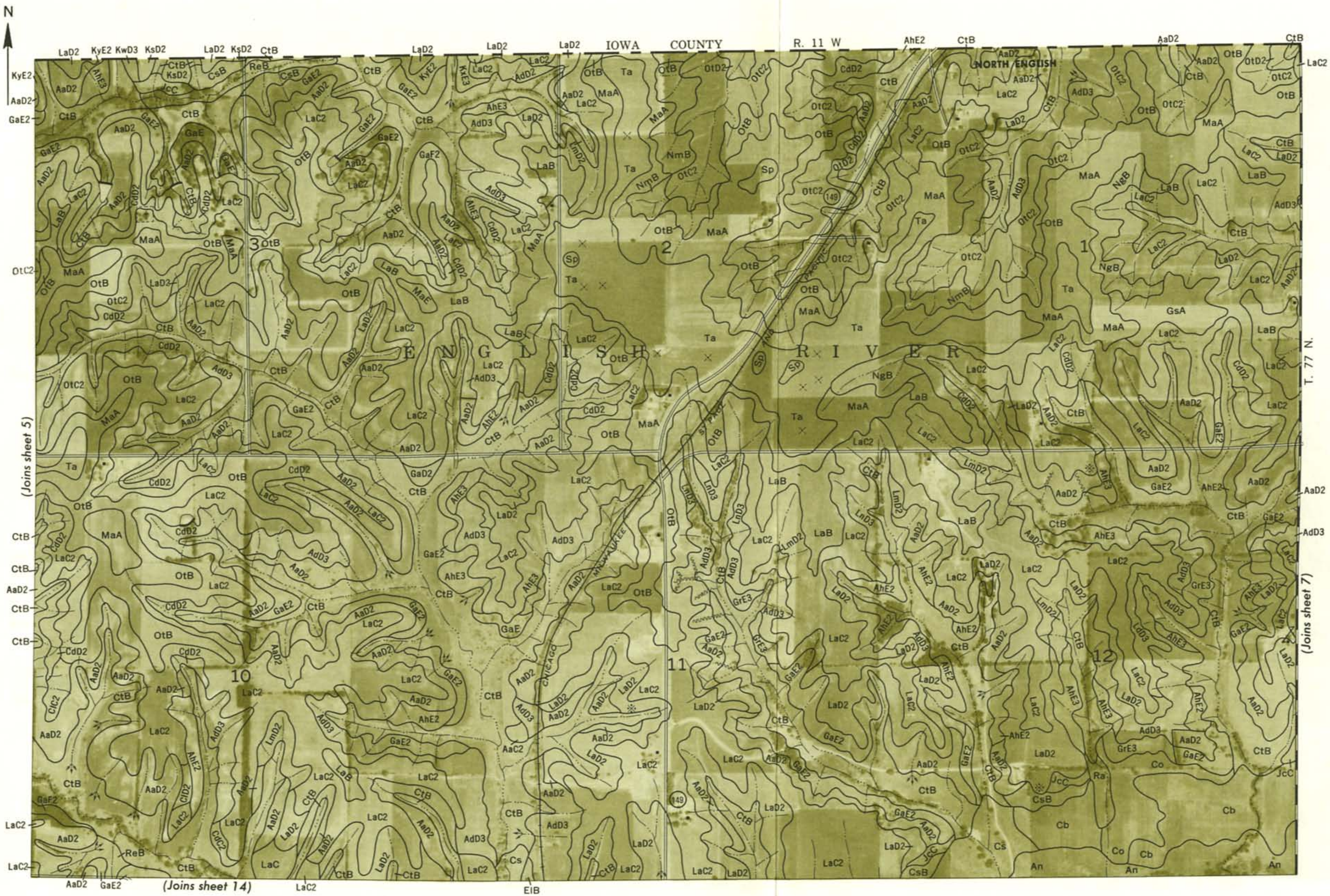

N
(Joins sheet 48)
R. 10 W.
T. 75 N.
(Joins sheet 55)
(Joins sheet 64)
CLEAR CREEK
WASHINGTON COUNTY
1
2
3
10
11
12


N
(Joins sheet 49)
R. 13 W.
T. 75 N.
MAHASKA COUNTY
(Joins sheet 58)
(Joins sheet 65)
W A R R E N
Union Chapel
18
17
16
19
20
21

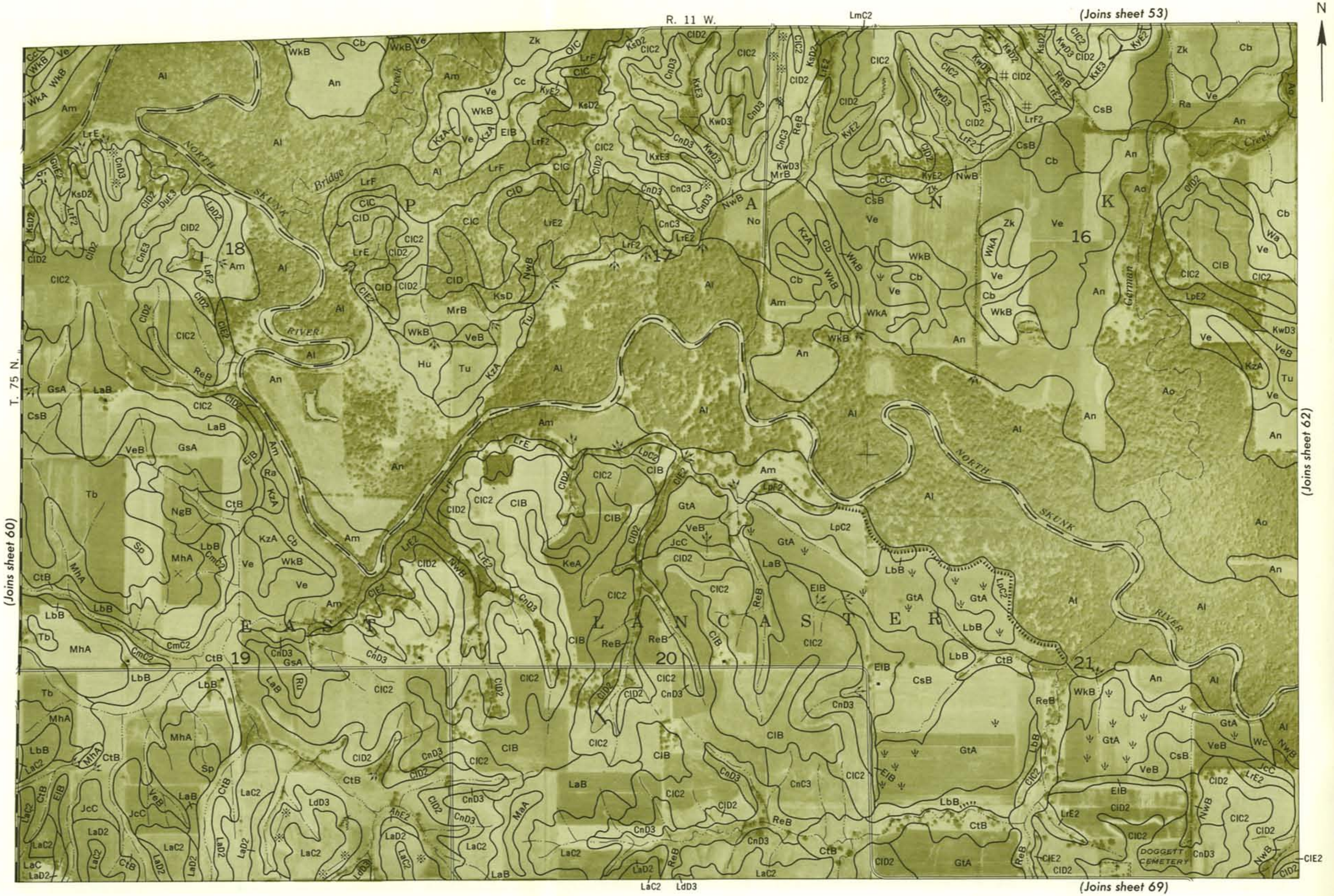

N
(Joins sheet 50)
R. 13 W.
T. 75 N.
(Joins sheet 57)
(Joins sheet 59)
(Joins sheet 66)
NORTH SKUNK RIVER
NORTH SKUNK RIVER
KENSLER CEMETERY
LIMESTONE QUARRY
Bethel Church
W A R R E N
13
14
15
22
23
24


N
(Joins sheet 51)
R. 12 W.
T. 75 N.
(Joins sheet 58)
(Joins sheet 60)
(Joins sheet 67)
S I G O U R N E Y
W E S T L A N C A S T E R
NORTH SKUNK RIVER
Newkirk School
16
17
18
19
20
21

KEOKUK COUNTY, IOWA — SHEET NUMBER 6




N
(Joins sheet 52)
(Joins sheet 59)
(Joins sheet 61)
(Joins sheet 68)
R. 12 W.
T. 75 N.
SIGOURNEY
WEST LANCASTER
NORTH SKUNK RIVER
CONNER CEMETERY
SIGOURNEY AIRPORT
CHICAGO MILWAUKEE ST PAUL AND PACIFIC
Troublesome Creek
149
13
14
15
22
23
24

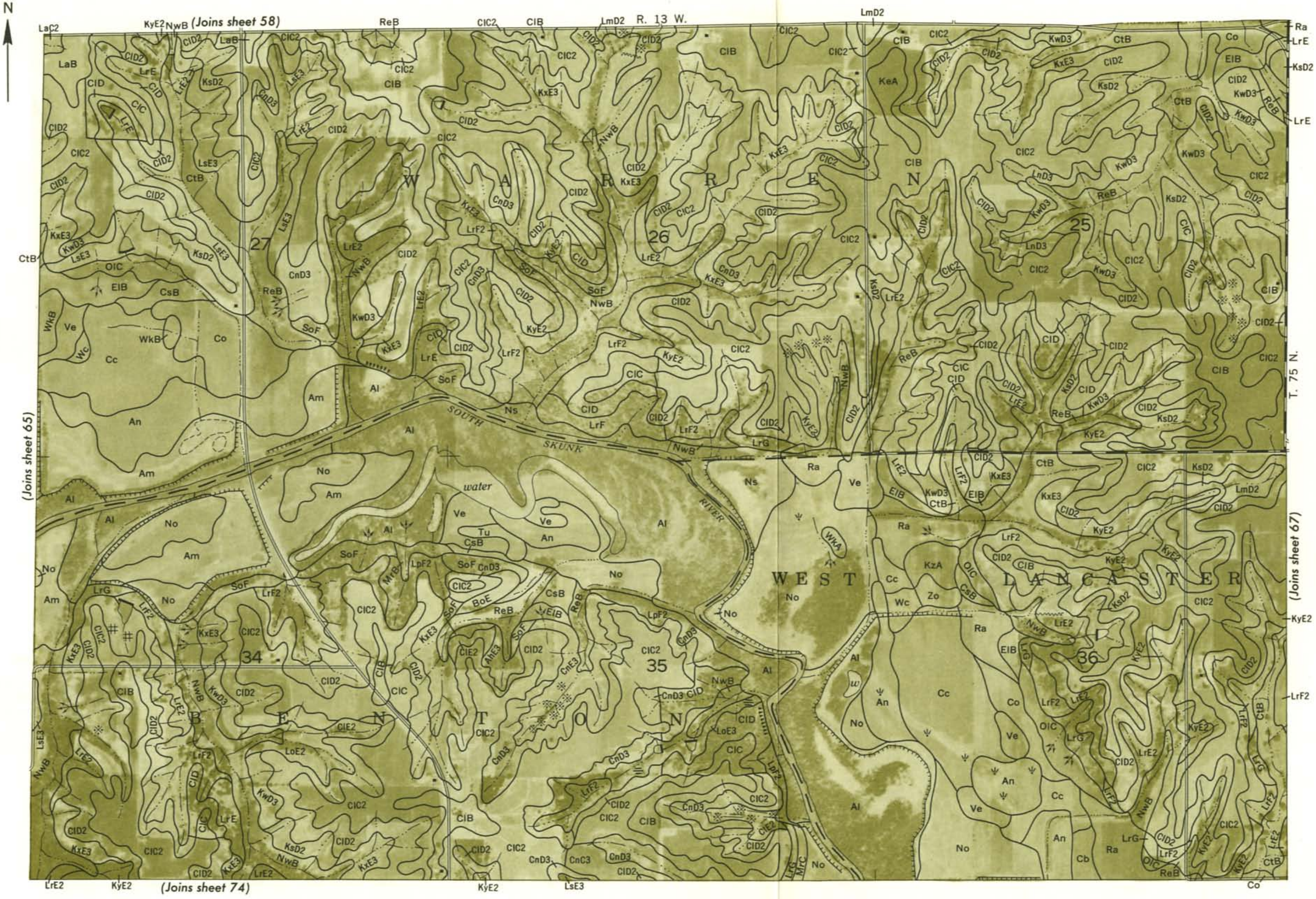

N
R. 11 W.
(Joins sheet 53)
T. 75 N.
(Joins sheet 60)
(Joins sheet 62)
(Joins sheet 69)
NORTH SKUNK RIVER
NORTH SKUNK RIVER
Bridge Creek
German Creek
PLANK
EAST LANCASTER
16
17
18
19
20
21
DOGGETT CEMETERY


N
(Joins sheet 54)
R. 11 W.
T. 75 N.
(Joins sheet 61)
(Joins sheet 63)
(Joins sheet 70)
15
14
13
22
23
24
P L A N K
E A S T
L A N C A S T E R
NORTH SKUNK RIVER
SKUNK RIVER
EAST LANCASTER

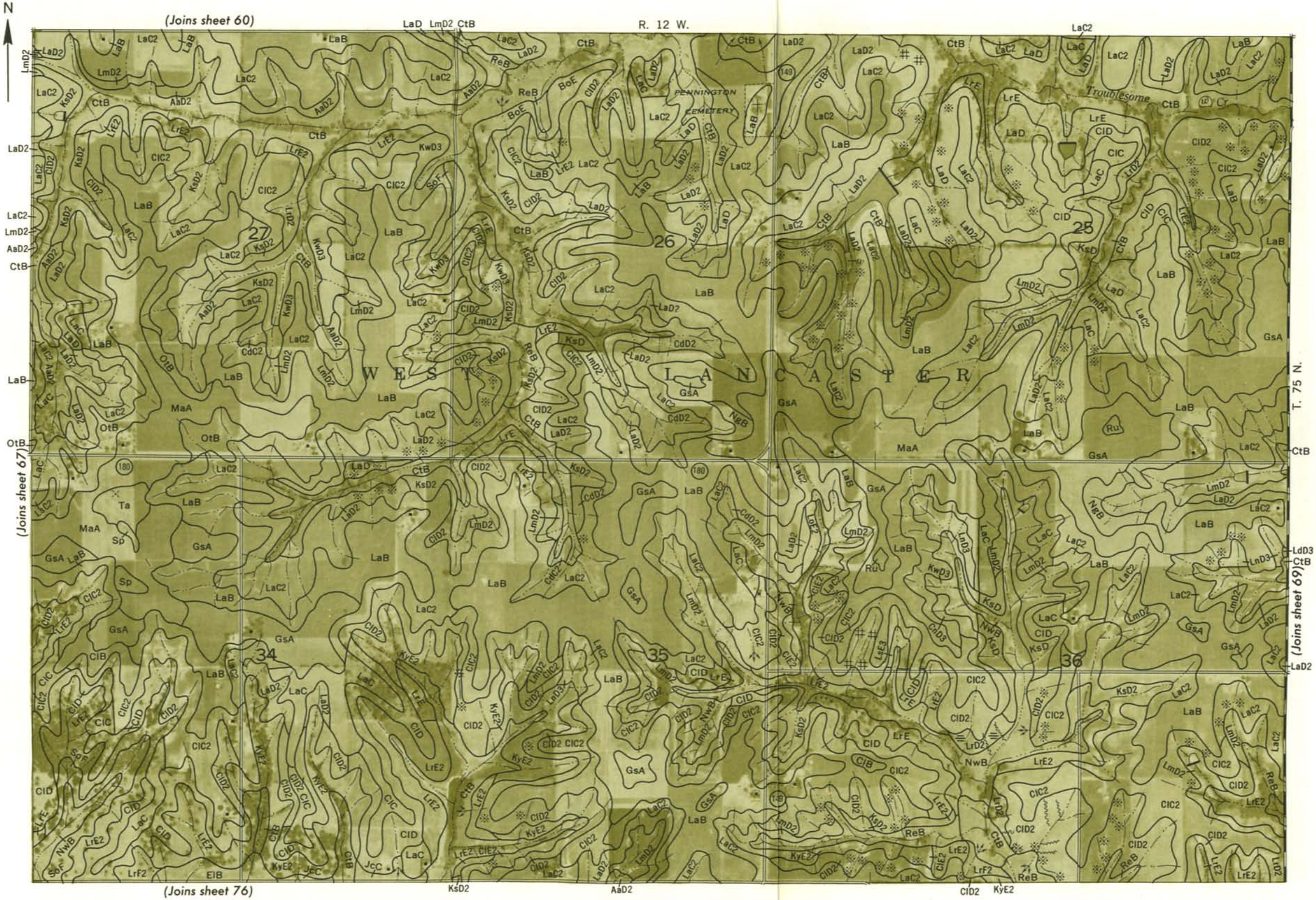

R. 10 W.
T. 75 N.
N
CtB (Joins sheet 55)
(Joins sheet 64)
(Joins sheet 62)
(Joins sheet 71)
CLEAR CREEK
S.S Peter & Paul School
18
17
16
19
20
21
1 Mile


N
(Joins sheet 56)
R. 10 W.
(Joins sheet 63)
T. 75 N.
WASHINGTON COUNTY
CLEAR CREEK
Talleyrand
Creek
15
14
13
22
23
24
(Joins sheet 72)


N
R. 13 W.
(Joins sheet 57)
(Joins sheet 66)
(Joins sheet 73)
T. 75 N.
MAHASKA COUNTY
W A R R E N
B E N T O N
SOUTH SKUNK RIVER
Mellot
QUARRY
LIMESTONE QUARRY
28
29
30
31
32
33

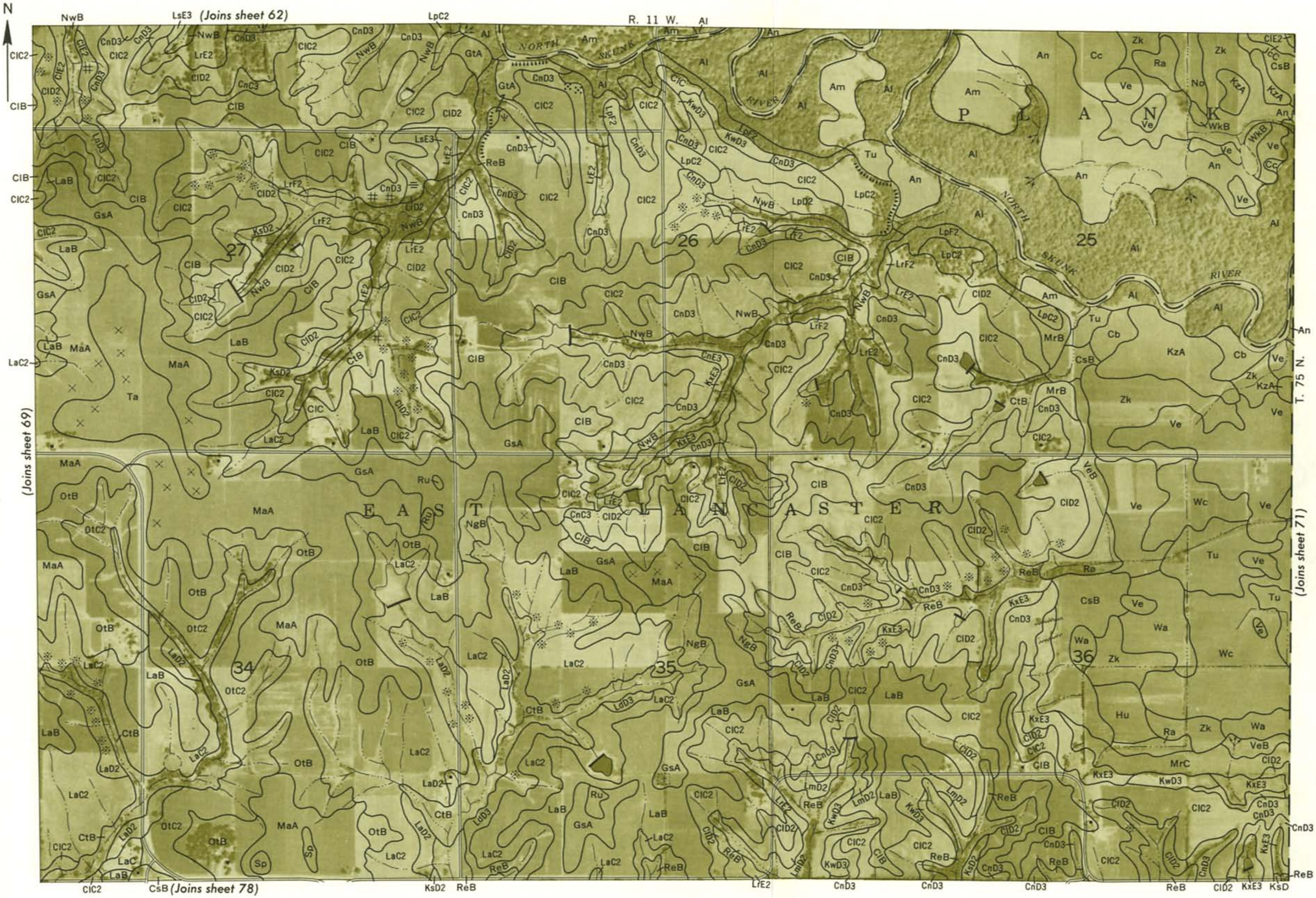

N
(Joins sheet 58)
R. 13 W.
T. 75 N.
(Joins sheet 65)
(Joins sheet 67)
(Joins sheet 74)
W A R R E N
WEST LANCASTER
B E N T O N
SOUTH SKUNK RIVER
water
25
26
27
34
35
36


N
R. 12 W.
T. 75 N.
(Joins sheet 59)
(Joins sheet 66)
(Joins sheet 68)
(Joins sheet 75)
WEST LANCASTER
Hayesville
28
29
30
31
32
33
CHICAGO MILWAUKEE ST. PAUL AND PACIFIC

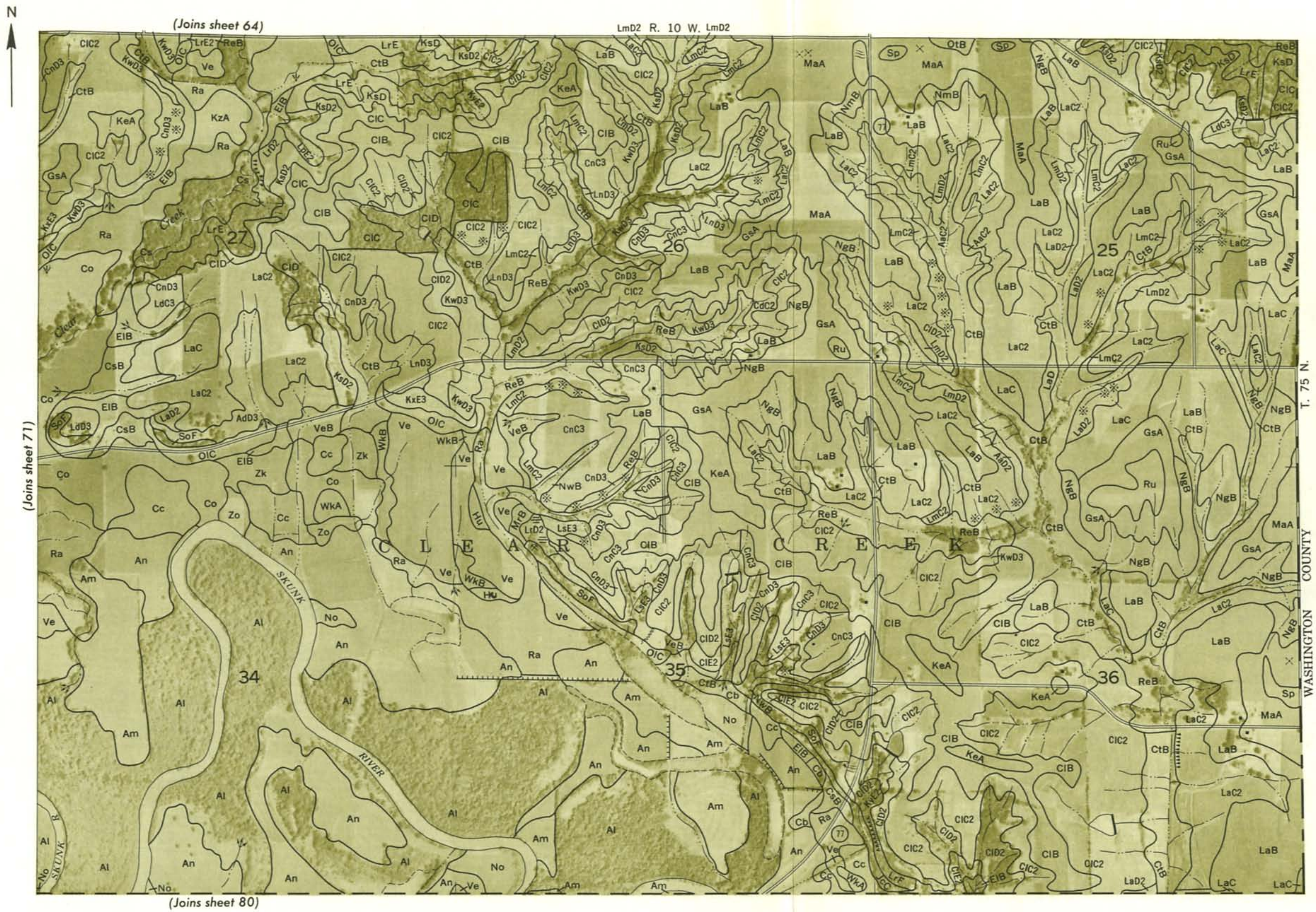

N
(Joins sheet 60)
R. 12 W.
T. 75 N.
(Joins sheet 67)
(Joins sheet 69)
(Joins sheet 76)
WEST LANCASTER
PENNINGTON CEMETERY
Troublesome Cr
25
26
27
34
35
36


(Joins sheet 61)
N
R. 11 W.
T. 75 N.
(Joins sheet 68)
(Joins sheet 70)
(Joins sheet 77)
Lancaster
Troublesome Creek
EAST LANCASTER
28
29
30
31
32
33

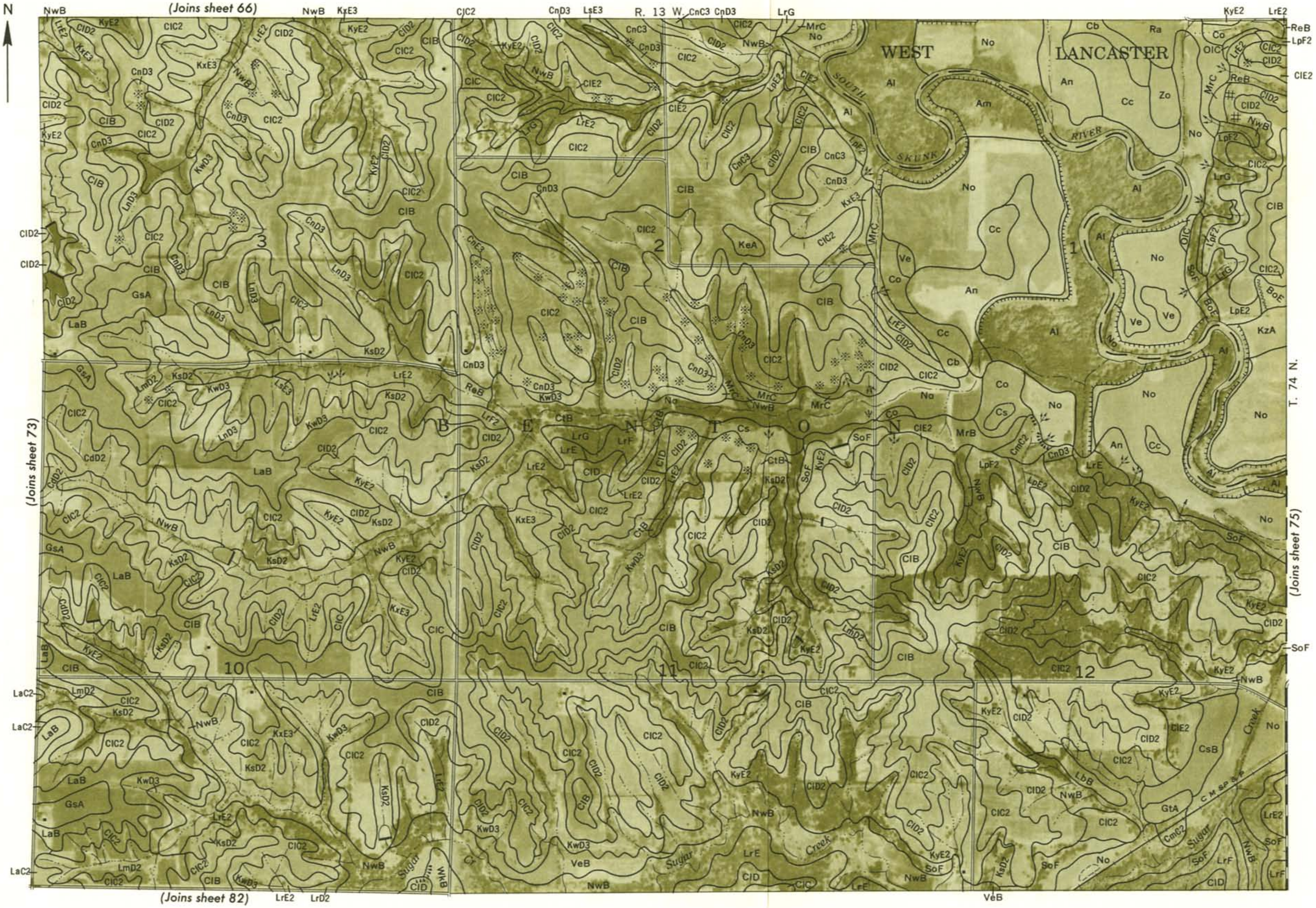

N
R. 10 W.
IOWA COUNTY
T. 77 N.
(Joins sheet 6)
(Joins sheet 8)
(Joins sheet 15)
Little Creek
L I B E R T Y
6
5
4
7
8
9


N
(Joins sheet 62)
R. 11 W.
T. 75 N.
(Joins sheet 69)
(Joins sheet 71)
(Joins sheet 78)
NORTH SKUNK RIVER
PLANK
EAST LANCASTER
25
26
27
34
35
36

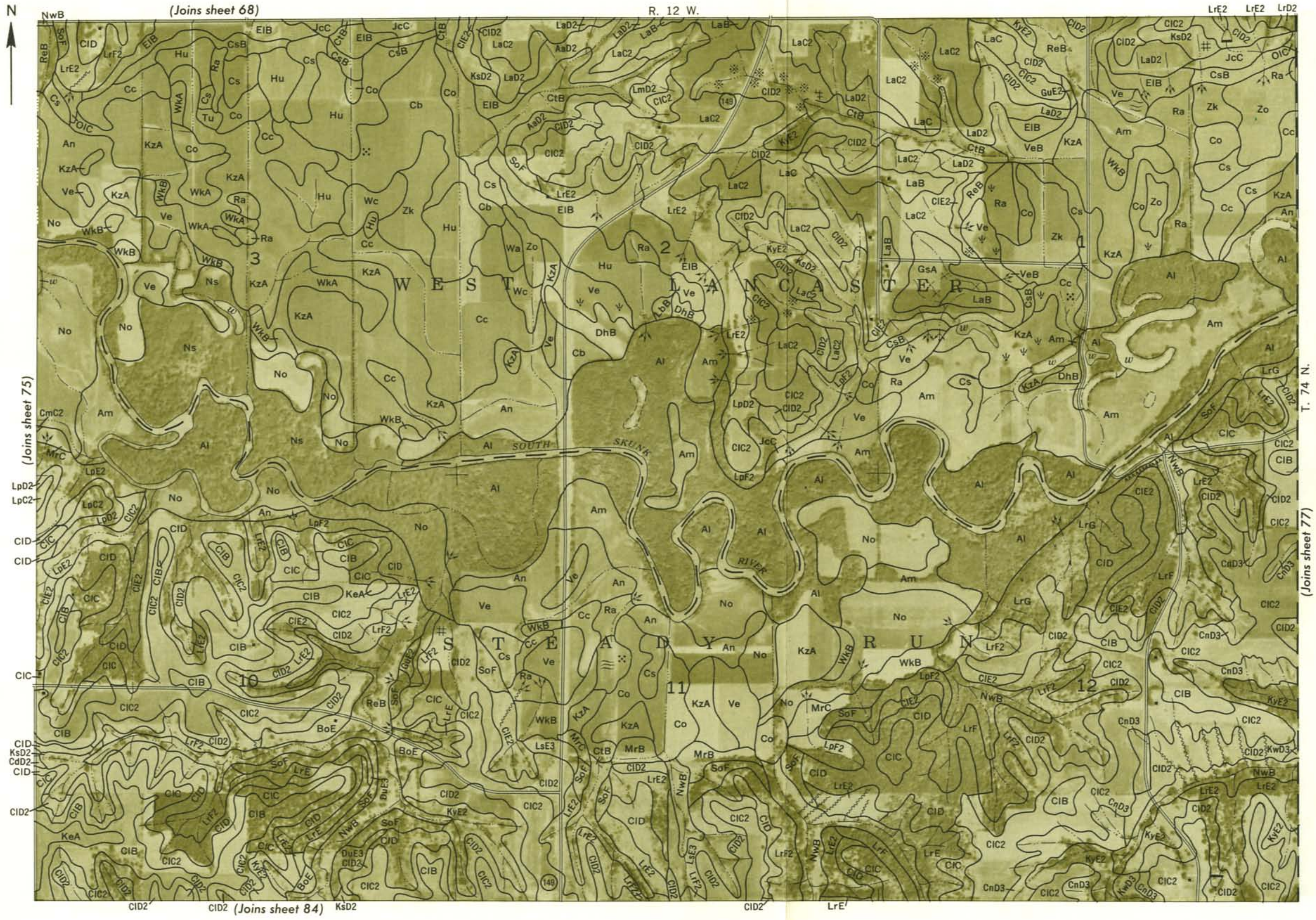

N
(Joins sheet 63)
R. 10 W.
T. 75 N.
(Joins sheet 70)
(Joins sheet 72)
(Joins sheet 79)
30
29
28
31
32
33
C L E A R C R E E K
NORTH
SKUNK
RIVER
SKUNK
RIVER


N
(Joins sheet 64)
R. 10 W.
(Joins sheet 71)
T. 75 N.
WASHINGTON COUNTY
(Joins sheet 80)
CLEAR CREEK
SKUNK RIVER
27
26
25
34
35
36

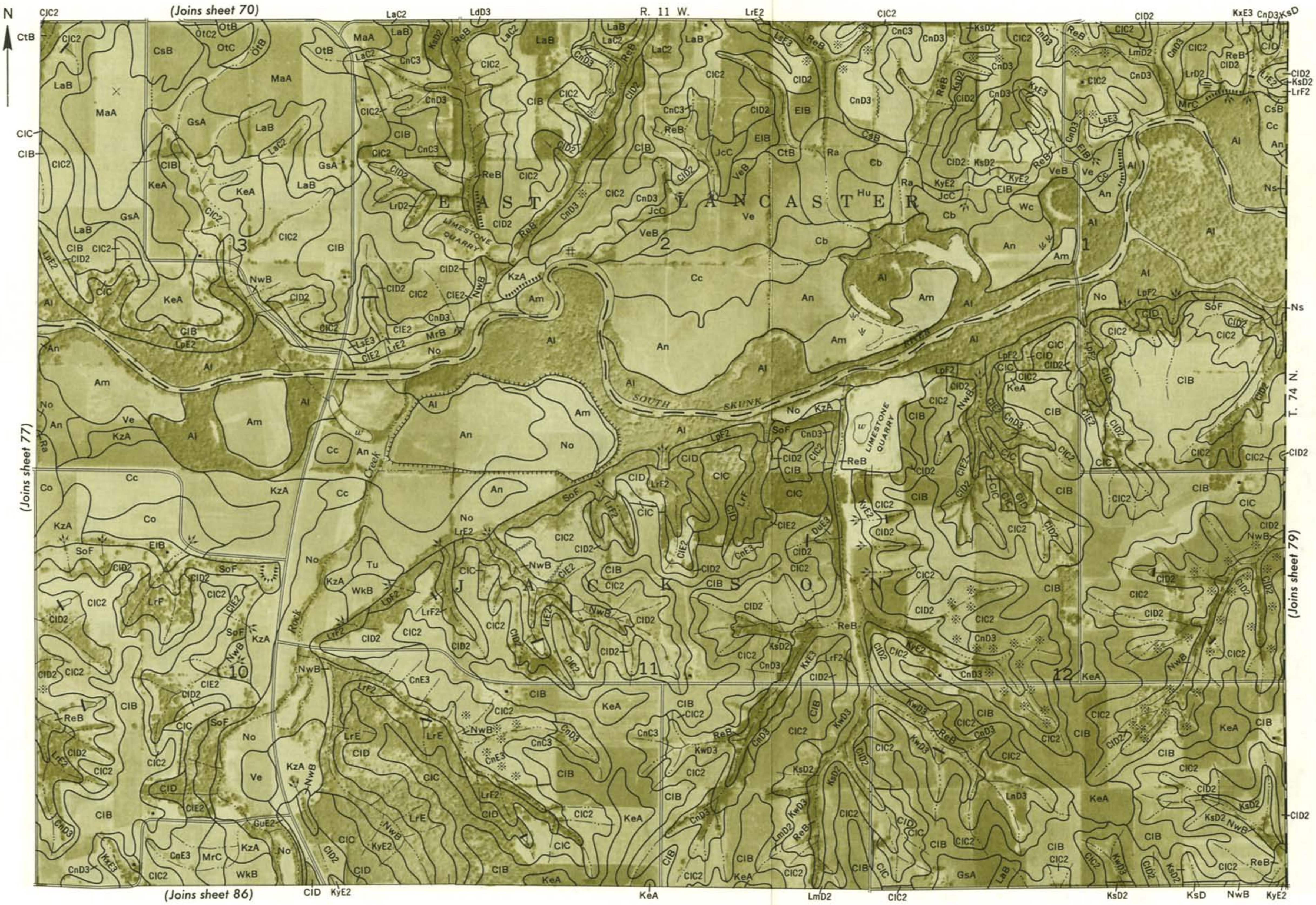

(Joins sheet 65)
R. 13 W.
N
T. 74 N.
MAHASKA COUNTY
(Joins sheet 74)
(Joins sheet 81)
BENTON
QUARRY


N
(Joins sheet 66)
R. 13 W.
WEST
LANCASTER
SOUTH SKUNK RIVER
B E N T O N
T. 74 N.
(Joins sheet 73)
(Joins sheet 75)
(Joins sheet 82)
Sugar Creek
C M St P & P
1
2
3
10
11
12

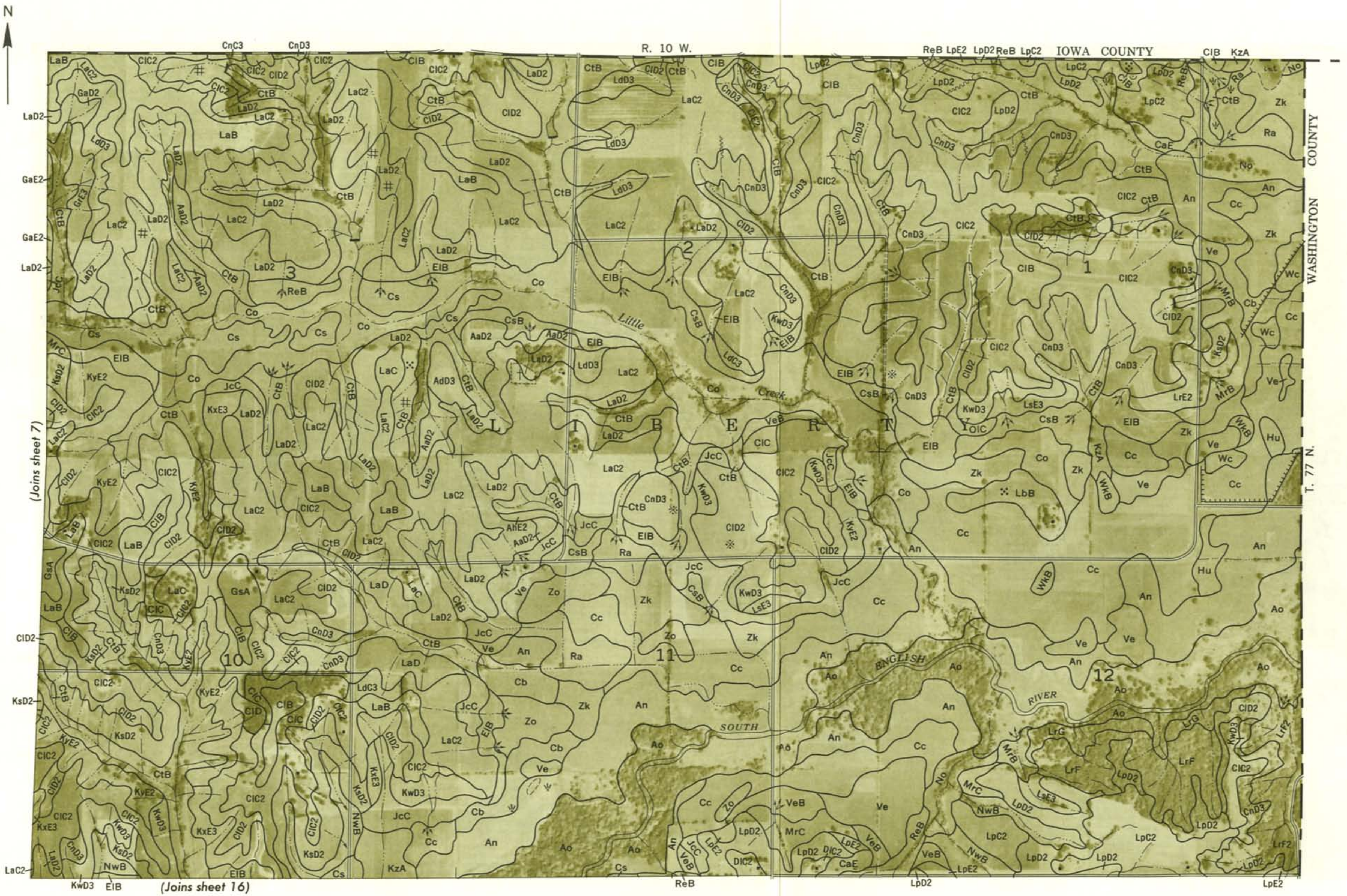

(Joins sheet 67)
R. 12 W.
N
WEST LANCASTER
STEADY RUN
T. 74 N.
(Joins sheet 74)
(Joins sheet 76)
(Joins sheet 83)
SKUNK RIVER
Sugar Creek
Steady Run
Creek
CHICAGO MILWAUKEE ST PAUL PACIFIC
4
5
6
7
8
9


N
(Joins sheet 68)
R. 12 W.
(Joins sheet 75)
(Joins sheet 77)
T. 74 N.
(Joins sheet 84)
WEST LANCASTER
STEADY RUN
SOUTH SKUNK RIVER
1
2
3
10
11
12

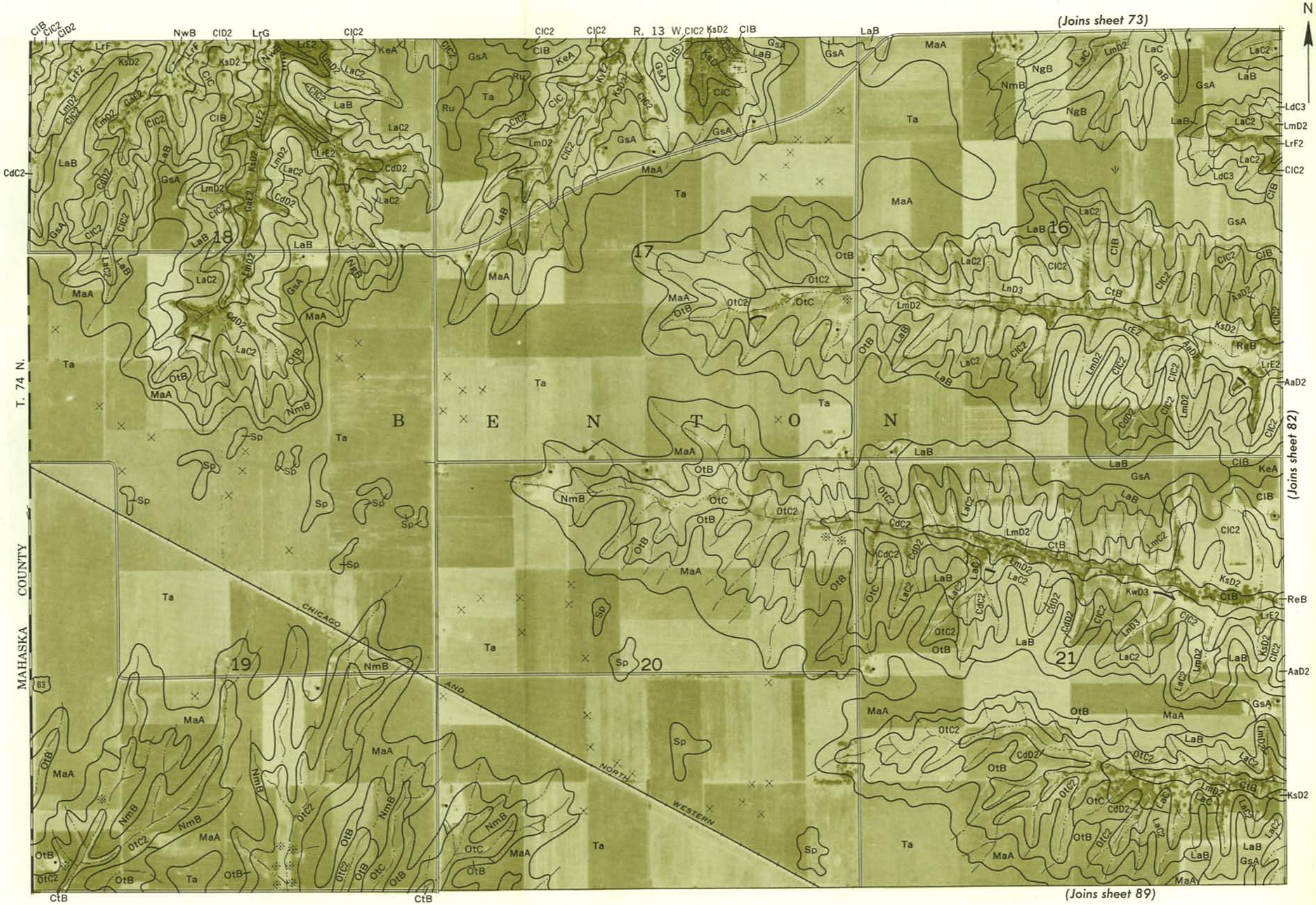

R. 11 W.
(Joins sheet 69)
N
EAST LANCASTER
SOUTH SKUNK RIVER
T. 74 N.
(Joins sheet 76)
(Joins sheet 78)
JACKSON
(Joins sheet 85)

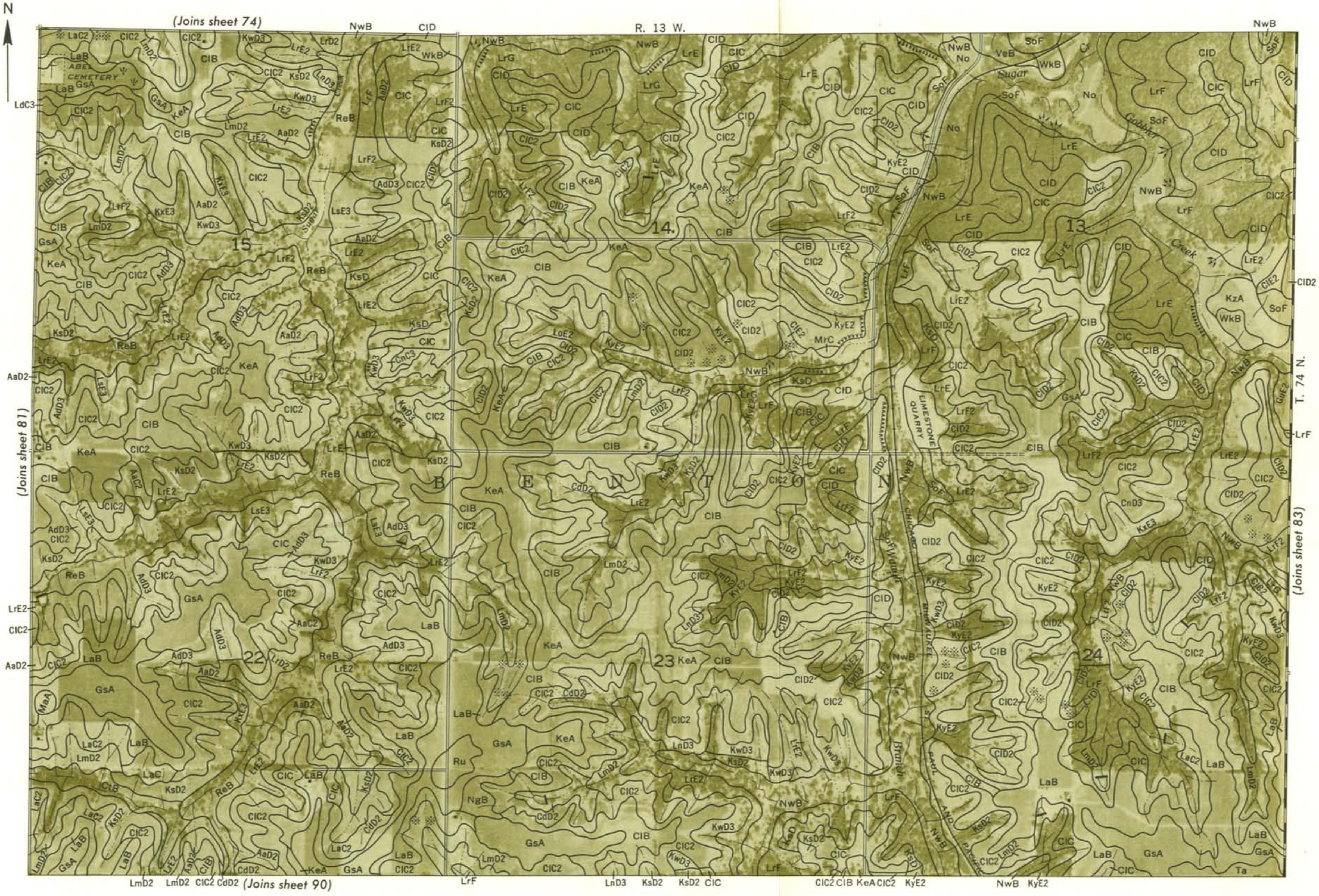

N
(Joins sheet 70)
R. 11 W.
T. 74 N.
(Joins sheet 77)
(Joins sheet 79)
(Joins sheet 86)
EAST LANCASTER
JACKSON
SOUTH SKUNK RIVER
LIMESTONE QUARRY
LIMESTONE QUARRY
Rock Creek
1
2
3
10
11
12


R. 10 W.
(Joins sheet 71)
N
(Joins sheet 80)
(Joins sheet 87)
(Joins sheet 78)
T. 74 N.
SOUTH SKUNK RIVER
SKUNK RIVER
R I C H L A N D
4
5
6
7
8
9

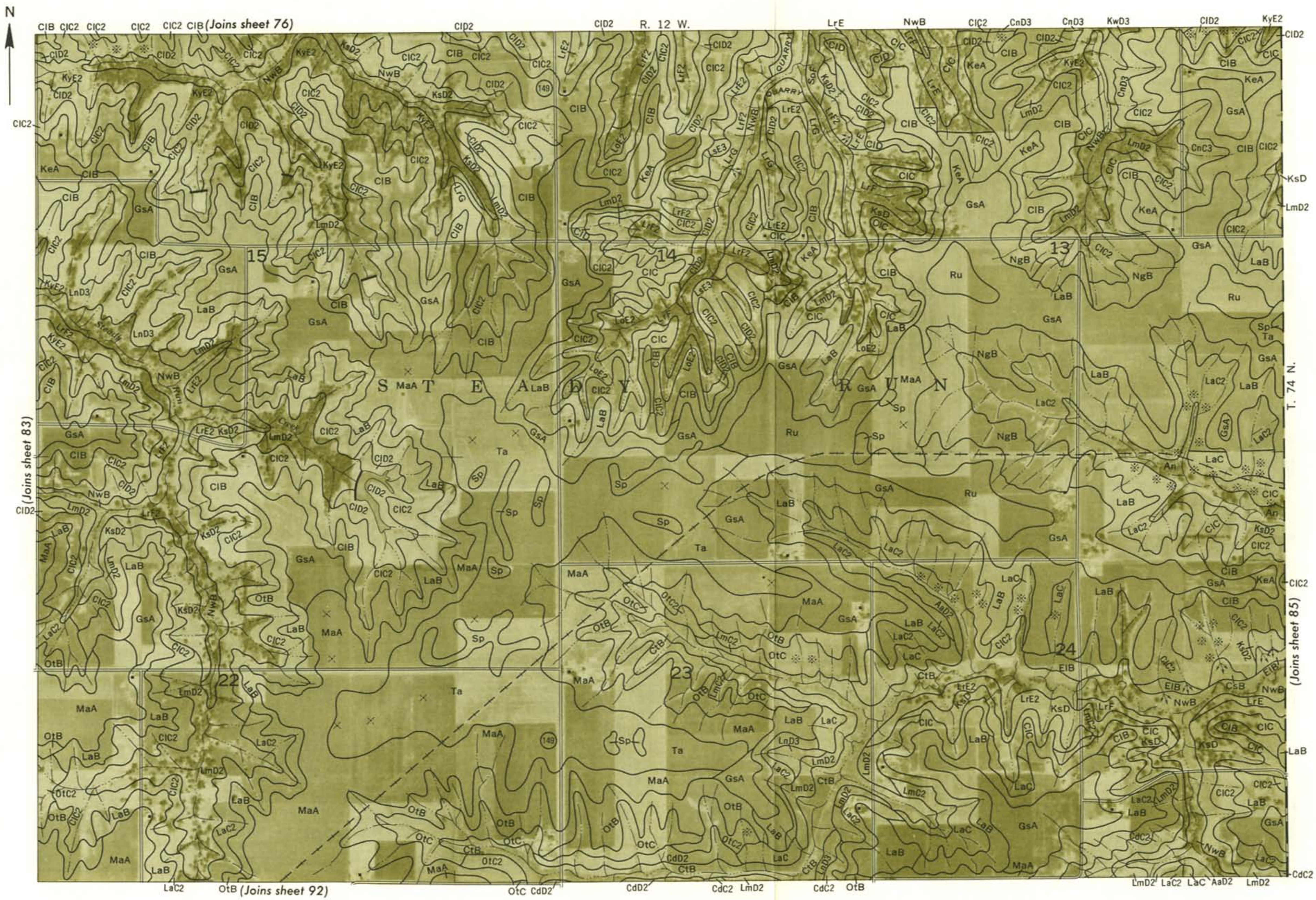

N
R. 10 W.
IOWA COUNTY
WASHINGTON COUNTY
T. 77 N.
(Joins sheet 7)
(Joins sheet 16)
Little
Creek
L I B E R T Y
ENGLISH
RIVER
SOUTH

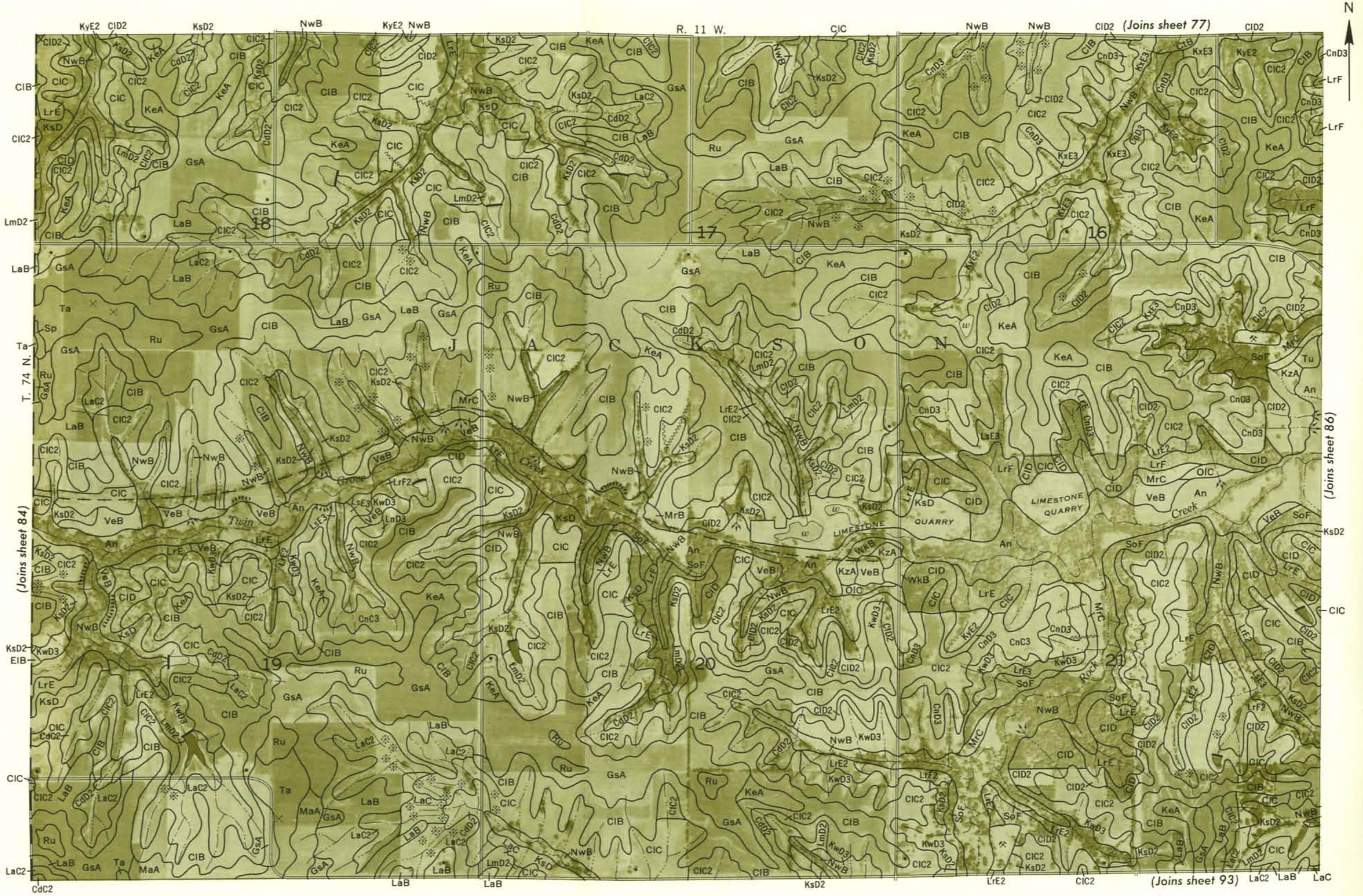

N
(Joins sheet 72)
R. 10 W.
(Joins sheet 79)
(Joins sheet 88)
T. 74 N.
WASHINGTON COUNTY
SKUNK RIVER
R I C H L A N D


(Joins sheet 73)
(Joins sheet 82)
(Joins sheet 89)
N
R. 13 W.
T. 74 N.
MAHASKA COUNTY
B E N T O N
CHICAGO AND NORTH WESTERN
16
17
18
19
20
21
63


N
(Joins sheet 74)
R. 13 W.
T. 74 N.
(Joins sheet 81)
(Joins sheet 83)
(Joins sheet 90)
ABEL CEMETERY
LIMESTONE QUARRY
Sugar
Gobbler
Creek
B E N T O N
15
14
13
22
23
24


(Joins sheet 75)
R. 12 W.
N
T. 74 N.
(Joins sheet 82)
(Joins sheet 84)
(Joins sheet 91)
18
17
16
19
20
21
STEADY RUN
Steady Run Creek
Goobter Creek
RAYBURN CEMETERY


N
(Joins sheet 76)
R. 12 W.
T. 74 N.
(Joins sheet 83)
(Joins sheet 85)
(Joins sheet 92)
STEADY RUN
15
14
13
22
23
24
149
QUARRY


N
R. 11 W.
T. 74 N.
(Joins sheet 77)
(Joins sheet 86)
(Joins sheet 93)
(Joins sheet 84)
J A C K S O N
18
17
16
19
20
21
Twin
Grove
Creek
Creek
Rock
LIMESTONE QUARRY
LIMESTONE
QUARRY


N
(Joins sheet 78)
R. 11 W.
T. 74 N.
(Joins sheet 85)
(Joins sheet 87)
(Joins sheet 94)
JACKSON
Ollie
Rock Creek
QUARRY
15
14
13
22
23
24
304

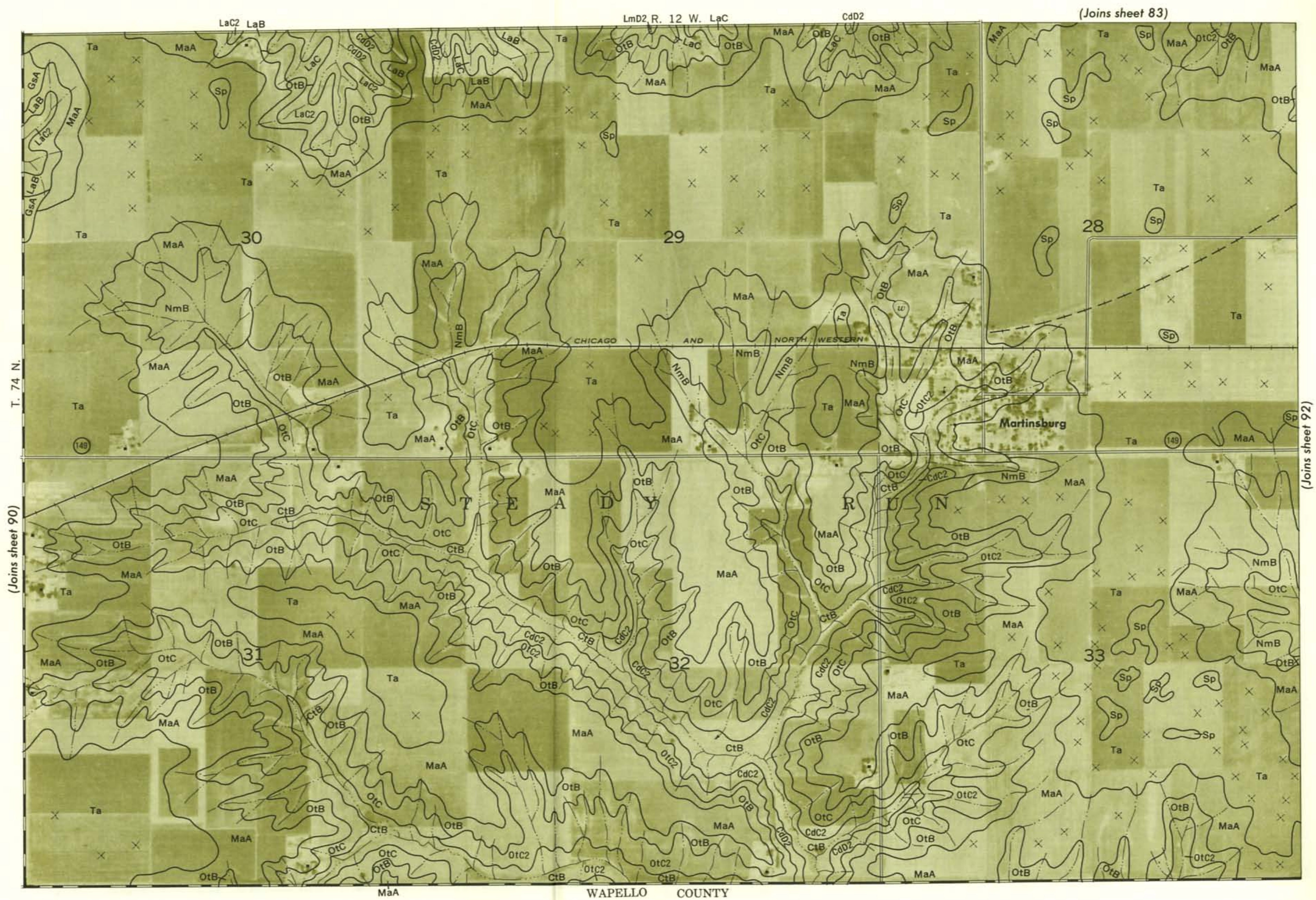

N
R. 10 W.
(Joins sheet 79)
(Joins sheet 88)
(Joins sheet 86)
(Joins sheet 95)
T. 74 N.
R I C H L A N D
18
17
16
19
20
21
Creek
Richland
C M St P & P R R

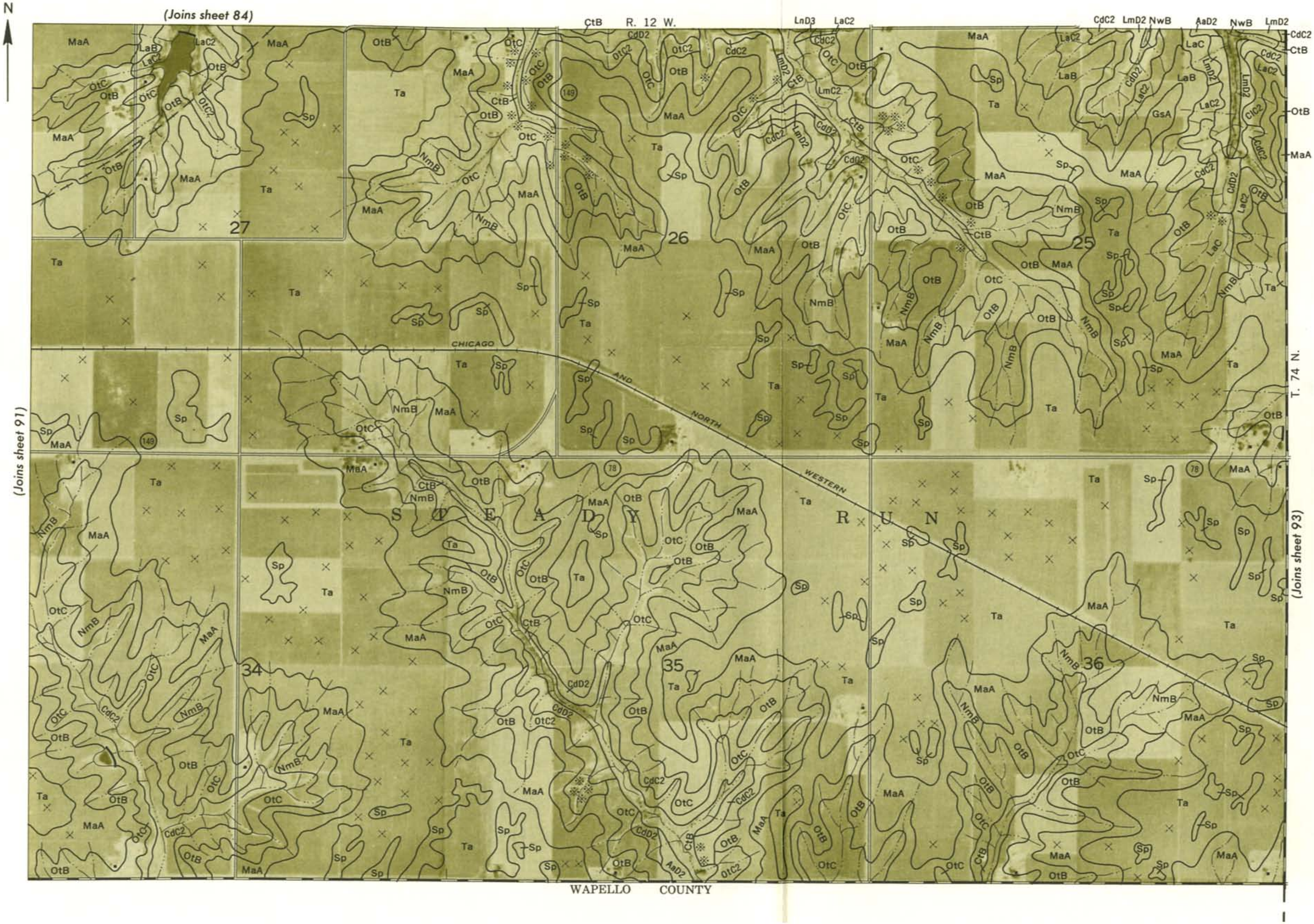

N
(Joins sheet 80)
R. 10 W.
(Joins sheet 87)
T. 74 N.
WASHINGTON COUNTY
(Joins sheet 96)
R I C H L A N D
Richland Creek
Richland
CHICAGO MILWAUKEE ST. PAUL AND PACIFIC
15
14
13
22
23
24
77


N
R. 13 W.
(Joins sheet 81)
(Joins sheet 90)
T. 74 N.
MAHASKA COUNTY
WAPELLO COUNTY
B E N T O N
30
29
28
31
32
33
Spring Creek
CHICAGO AND NORTH WESTERN
149
83


N
R. 13 W.
(Joins sheet 1)
(Joins sheet 10)
(Joins sheet 17)
T. 77 N.
MAHASKA COUNTY
Gibson
CHICAGO
ROCK
ISLAND
AND
PACIFIC
P R A I R I E
16
17
18
19
20
21

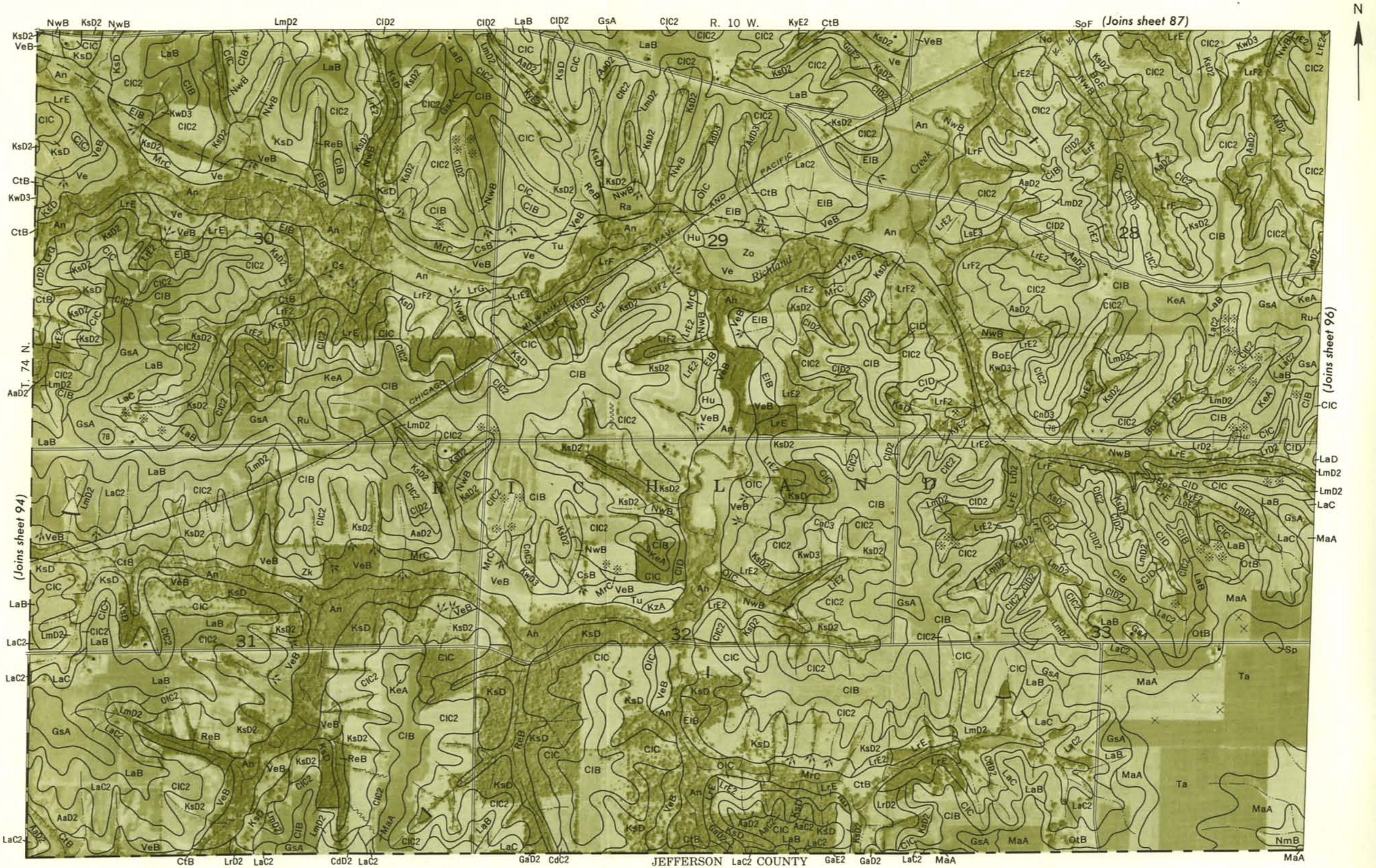

N
(Joins sheet 82)
R. 13 W.
T. 74 N.
(Joins sheet 89)
(Joins sheet 91)
WAPELLO COUNTY
27
26
25
34
35
36
BENTON
Hedrick
BROOKS CEMETERY
CHICAGO AND NORTH WESTERN
C & N W
MILWAUKEE
CHICAGO
149

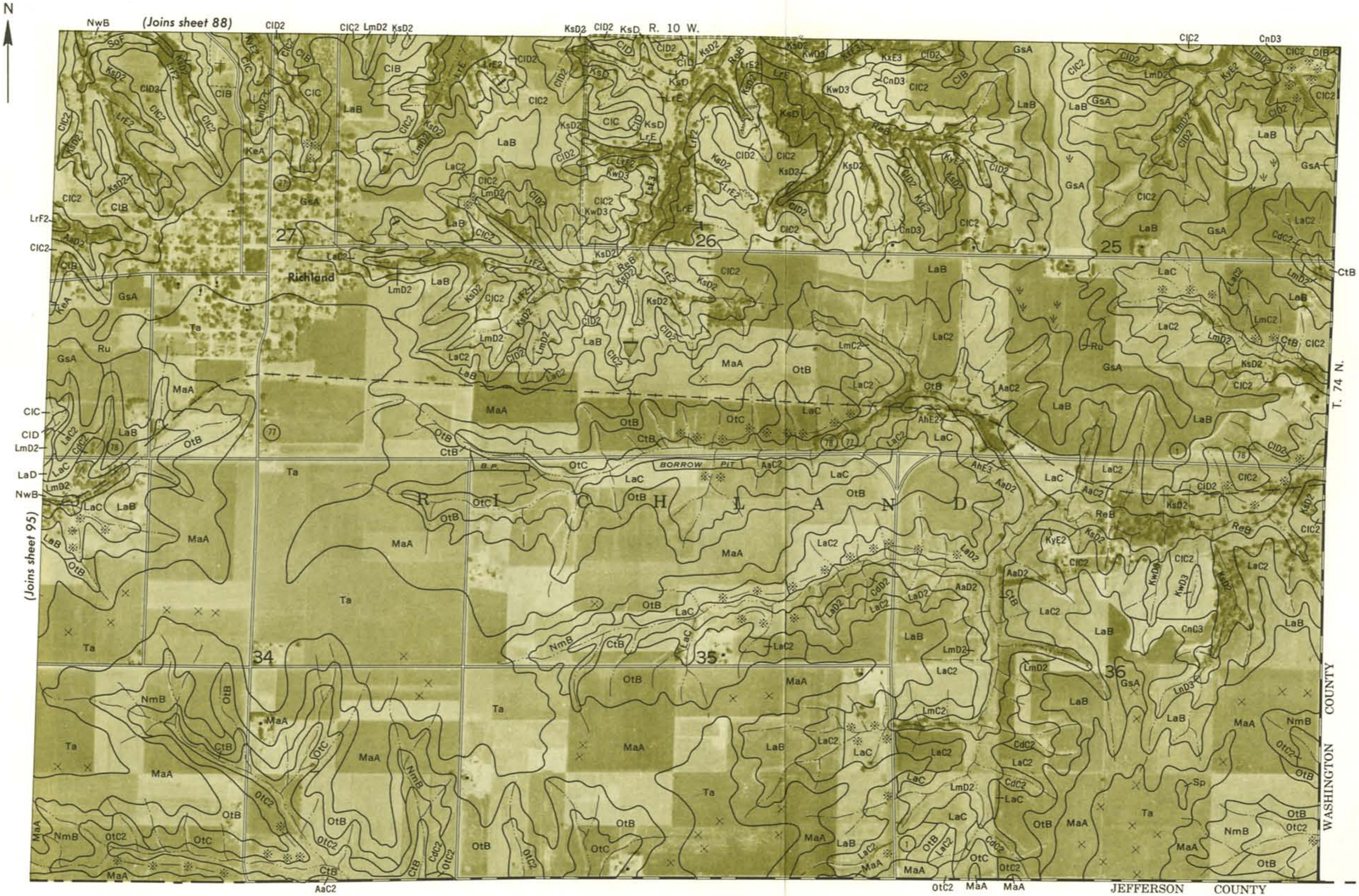

N
(Joins sheet 83)
R. 12 W.
T. 74 N.
(Joins sheet 90)
(Joins sheet 92)
30
29
28
31
32
33
CHICAGO AND NORTH WESTERN
Martinsburg
S T E A D Y R U N
149
WAPELLO COUNTY


N
(Joins sheet 84)
R. 12 W.
T. 74 N.
(Joins sheet 91)
(Joins sheet 93)
CHICAGO
AND
NORTH
WESTERN
S T E A D Y R U N
27
26
25
34
35
36
WAPELLO COUNTY


(Joins sheet 85)
R. 11 W.
N
T. 74 N.
(Joins sheet 92)
(Joins sheet 94)
JACKSON
30
29
28
31
32
33
ROCK QUARRY
Rock Creek
CHICAGO AND NORTH WESTERN
JEFFERSON COUNTY


N
(Joins sheet 86)
R. 11 W.
T. 74 N.
(Joins sheet 93)
(Joins sheet 95)
Richland Creek
J A C K S O N
27
26
25
34
35
36
304
78
CHICAGO MILWAUKEE ST PAUL AND PACIFIC
JEFFERSON COUNTY


N
(Joins sheet 87)
(Joins sheet 96)
(Joins sheet 94)
R. 10 W.
T. 74 N.
JEFFERSON COUNTY
RICHLAND
Richland
Creek
CHICAGO MILWAUKEE ST PAUL AND PACIFIC
28
29
30
31
32
33
78


N
(Joins sheet 88)
R. 10 W.
T. 74 N.
(Joins sheet 95)
27
26
25
34
35
36
Richland
R I C H L A N D
BORROW PIT
B P
WASHINGTON COUNTY
JEFFERSON COUNTY